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Parts Delays at Maintenance Depots
A Significant Problem

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This report examines awaiting parts (AWP) delays at maintenance depots of the Department of Defense (DoD). It provides evidence that AWP delays are not rare or brief. It also shows how they increase the cost to repair and how they could affect weapon system readiness adversely. The report investigates local parts support at the depots and how it can be improved to reduce AWP delays. It also reviews wholesale parts availability and how DoD can improve it. Finally, the report describes private-sector practices that can reduce AWP delays.

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Parts Delays at Maintenance Depots:
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Executive Summary

Parts delays cause inefficiency and ineffectiveness at Department of Defense (DoD) maintenance depots. To size the problem and identify corrective actions, the Deputy Under Secretary of Defense (Logistics) asked the Logistics Management Institute to conduct an awaiting parts (AWP) analysis.

AWP delays occur when parts needed by depots for repairing components or overhauling end items are not immediately available from the DoD supply system. We found the following:

- Although each military service records AWP occurrences differently, their records show significant AWP delays.
- AWP delays increase the cost to repair by causing depot personnel to work around parts shortages. However, quantifying the additional costs of AWP delays is difficult because the costs are aggregated in labor, materiel, and overhead.
- AWP delays disrupt depot scheduling and induction and extend depot flow times; and, most importantly, current AWP delays could degrade weapon system readiness if not addressed.

We found that retail inventories directly supporting maintenance depots are not meeting their designated issue effectiveness goals. We examined several procedures and events that contribute to poor support, including depot forecasting of repair parts and depot rules for stocking repair parts. We found that, although the dynamic usage of parts makes eliminating all retail part shortages impossible, the models that forecast depot demand and set inventory levels for parts can be improved.

At the wholesale level, the Defense Logistics Agency (DLA), the principal wholesale supplier for depot repair parts, has improved its depot support by assigning representatives at each maintenance depot. However, problems still exist. One DLA supply center had low fill rates (67.4 percent) and long backorder times (an average of 406 days) for AWP requisitions. We found that procurement

problems and shortages of low demand frequency items caused many backorder delays.

Based on our assessment of best practices in the public and private sectors, we recommend the following to improve retail and wholesale parts availability and reduce AWP delays:

- The military services should reassess their retail stockage policies and practices at their maintenance depots. The goal should be high levels of issue effectiveness. To determine how high local retail support targets should be, the military services should trade off increases in inventory investment against the costs of AWP delays. The military services may want to consider the following actions to offset any investment increases:
  - Replace current models that determine when to stock an item (e.g., demands in a period) and how much to stock (e.g., days-of-supply models) with more effective models
  - Employ ABC inventory control (i.e., dividing parts into three groups by price and demand and applying tighter financial controls and lower stockage to high-cost parts than to low-cost parts)
  - For components with expensive parts and continuous and sizable repair requirements, use level scheduling to help stabilize the demand for the parts and thereby improve the effectiveness of inventory levels.
- DLA should extend its efforts to replace single-item contracts with multi-item, multiyear contracts that reduce the potential for extended lead-times.
- DLA should reassess its stockage policy for low demand frequency items to determine if it can be improved by including lead-times in reorder point computations and accommodating peaks in long-term demand patterns in requirements objectives.
- The military services and DLA should jointly seek ways to improve the transfer and use of programmed depot parts requirements.
- The military services and DLA should work to eliminate rejected depot requisitions due to out-of-date item stockage codes.
- To evaluate potential initiatives for reducing AWP delays, the military services should establish common metrics for tracking and measuring AWP delays and develop systems for tracking costs attributable to AWP delays. The metrics and systems could be used to measure the progress of initiatives.

The above recommendations are all aimed at improving the effectiveness and efficiency of the supply chain for parts used by depots.

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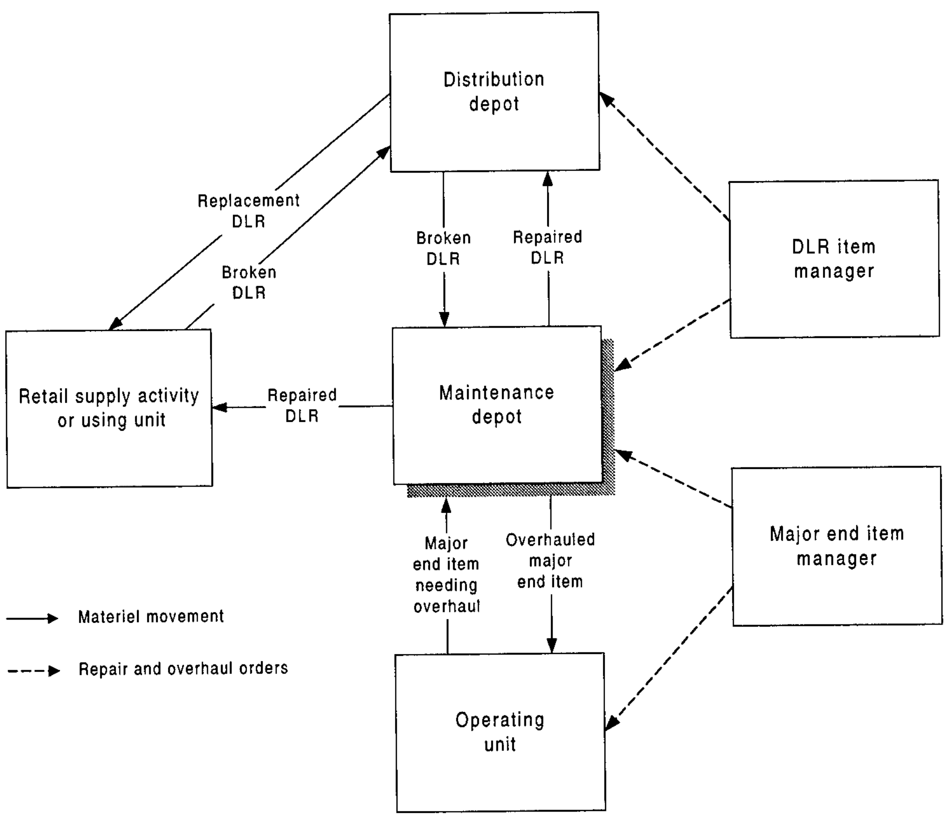
Chapter 1
Overview

The Department of Defense (DoD) uses public and private maintenance depots to repair and overhaul repairable end items. End items include major end items (e.g., aircraft and combat vehicles), engines, and depot-level reparable (DLR) items. An "awaiting parts" (AWP) delay occurs when a depot encounters a delay in obtaining a repair part needed to complete the repair or overhaul of an end item. This study examines how AWP delays are recorded at public maintenance depots and how they can be reduced.

BACKGROUND

Figure 1-1 is a simplified sketch of the materiel flows to and from DoD maintenance depots.

Figure 1-1. Materiel Flows



As DoD units use equipment to carry out their missions, components fail and cause the equipment to be inoperable. In many cases, the failed component is a

DLR item that cannot be repaired by the unit and is returned to the DoD wholesale level for repair. Depending on the need for the item, it is sent to a maintenance depot for immediate repair, or stored in a distribution depot and scheduled for repair when needed.

In addition to the repair of failed components, depots also overhaul major end items. They are overhauled periodically to eliminate any degradation in their availability or to incorporate modifications that improve their mission effectiveness. Managers of major end items schedule the overhauls with a maintenance depot.

WHY STUDY AWP

The Deputy Under Secretary of Defense (Logistics) asked the Logistics Management Institute (LMI) to conduct this study to determine if AWP delays constitute a significant problem and, if so, identify actions to reduce them. When repair parts are not available, repair of end items stops until the parts are available. Work stoppages increase depot throughput times and the cost of repair.

DoD maintenance managers can avoid those negative consequences if AWP delays are rare and brief. However, data collected in this study indicate that AWP delays are *not* rare or brief. The military services record AWP delays for 7 to 22 percent of all depot repairs and an average delay of 108 to 269 days. In addition, our analysis indicates that current levels of AWP delays may severely degrade readiness if uncorrected.

How AWP Affects Maintenance

AWP affects maintenance in two ways. First, as mentioned above, an AWP delay can stop work for an item already inducted into the repair process. Another way AWP affects maintenance is when a repair order must wait to be scheduled because a preinduction parts check reveals that necessary parts are not available.

Faced with these delays, depot personnel engage in several actions, often referred to as "workarounds," to overcome parts shortages. The cost of performing the extraordinary measures significantly increases production cost (one depot manager we interviewed estimated 17 percent), which is charged to the depot's customers. Consequently, an AWP delay increases the time and cost to perform depot maintenance.

How AWP Affects Supply

AWP affects supply in one of two ways depending on whether AWP delays are included in the repair cycle times that go into to setting inventory levels for DLR items. If AWP delays are included, then the resulting inventory levels may be higher than they need to be to cover demand while the items are being repaired.

This is particularly true if AWP delays are sporadic. If AWP delays are excluded, then the resulting inventories may not provide the expected level of support, since the assets flow out of repair slower than expected. This is particularly true when AWP delays are a recurring problem. In looking at how the military services compute their repair cycle times, we found all cases; that is, AWP delays are wholly or partially included, or they are excluded.

TASKS

We divided our study of the AWP problem into three tasks—sizing the problem, identifying causes, and recommending solutions that could reduce AWP. To accomplish the tasks, we focused on aviation depot maintenance in each military service and added combat vehicle maintenance in the Army to provide another category of logistics support.

Sizing the Problem

To verify that AWP is a significant problem, we compiled data on the frequency, duration, and impacts of AWP delays on depot repair programs, inventory investment, and weapon system readiness.

AWP FREQUENCY AND DURATION

We found that the military services record and measure AWP delays differently. However, the statistics we compiled show AWP delays to be a significant and increasing problem for depot maintenance, adding between 18 and 24 days to the average repair cycle time of the military services.

FINANCIAL AND OPERATIONAL IMPACTS

We were able to confirm the following:

- AWP increases maintenance costs. However, the increases are concealed in the categories for monitoring the labor, materiel, and overhead costs of repair.
- AWP increases supply costs, but the increases are hidden in the cost of inventory levels for DLR items.
- AWP adversely affects depot operations and weapon system readiness (the exact level of degradation depends on the weapon system and on the extent that workarounds can damper the affect).
- AWP disrupts the proper scheduling of repairs and significantly extends the cycle times of some DLR items.

Metrics to Measure AWP Delays and Costs

Each service collects a variety of statistics on its AWP delays. However, the statistics have the following disadvantages:

- They differ by military service and, therefore, do not provide maintenance managers and suppliers, such as the Defense Logistics Agency (DLA), with a basis for judging where AWP delays are occurring with the greatest frequency and duration and causing the critical work stoppages.
- They often are constrained by minimum time restrictions; that is, AWP incidents that do not exceed set time limits are excluded. Therefore, they do not provide logistics managers with all the needed information on the frequency and duration of AWP delays.
- They often do not denote the severity and criticality of AWP incidents.

Identifying Causes

Using information from depots and suppliers, we looked at why parts are not available at the retail level and why they are not readily available from wholesale and vendor sources of supply.

However, we could not qualify the contribution of each cause for two reasons. First, no system identifies or otherwise assigns causes to AWP incidents. Second, the causes overlap. For example, if a part is not stocked locally and is not stocked at the DoD source of supply and if the manufacturer cannot deliver on time, is the problem with local supply support, wholesale supply support, or the manufacturer, or all three? In the following subsections, we review the causes of AWP that we focused on in our analyses.

Retail Parts Availability

At the depots we visited, we found that retail inventories were not meeting their support goals. We also found that the depots use a wide variety of algorithms to set their inventory levels.

We observed the efforts of the military services to improve their bills of materials (BOMs) to perform repair orders. Their objective was to improve their parts forecasts and thereby improve their level setting process.

However, although better BOMs might reduce some uncertainty in forecasting parts requirements, it does not eliminate all uncertainty. Besides the expected variance in the parts needed to perform repair, we found a significant variance between planned and actual inductions of end items in the repair process. We demonstrate that these two sets of variances cause high levels of error in parts forecasts even with improved BOMs.

Finally, we found that one service was significantly limiting its retail parts inventory as part of its efforts to reduce overall inventory. This action should only serve to increase AWP.

WHOLESALE PARTS AVAILABILITY

Inventory control points (ICPs) receive parts requisitions from depots as they do from other customers. In the case of AWP, the depots assign the requisitions a high-priority. However, we found that the level of support for those high-priority depot requisitions is not nearly as effective as it is for other requisitions.

That is, at the wholesale level, depot AWP requisitions are backordered at a greater rate than other requisitions and are on backorder longer. Wholesale backorders occur for several reasons. We focused on four areas—parts acquisition, management of low frequency demand items, demand forecasting, and requisition processing—identified by the AWP data we collected.

Parts Acquisition

One reason we found for more and longer backorders for parts causing AWP delays is that actual procurement lead-times are greater than those on file. DoD systems use lead-time data to determine when to buy. A buy is timed to arrive when the level of stock is expected to go to zero. If parts are received later than expected, then supply support suffers.

To reduce lead-times, particularly those that exceed the times used by the supply system, we investigated how parts acquisition could be improved. The changes that we identified are already being made, although not to the scale they should be. One change involves changing from one-time, one-part buying to long-term, multipart contracting with delivery orders. Other changes establish contract performance goals and require contractor compliance with them.

Management of Low Frequency Demand Parts

Low frequency demand parts are parts that are not stocked or only a low quantity is stocked (e.g., insurance stockage and numeric stockage objective [NSO] items). We found that they are a significant source of AWP delays.

We investigated the level-setting processes for these parts, primarily those managed by DLA. We found that level setting is not a function of a performance goal. We also found that reorder point computations do not account for lead-time differences between parts. Most notably, we found that the current method does not account for demand peaks that are characteristic of low-demand items.

Demand Forecasting

We examined the special program requirements (SPR) process that allows depots to send projected demands to their wholesale suppliers before requisitioning and

thereby improve the suppliers' ability to have parts available when requisitioned. We found that the SPR process is not being fully utilized and has limitations that reduce its effectiveness.

Requisition Processing

We looked at the processing of depot requisitions and found rejected requisitions that could have been avoided if the requisitioner or DLA had the correct item coding for the part being requisitioned.

Recommending Solutions

In seeking solutions to the problems causing AWP delays, we looked for best practices in public- and private-sector activities involved in repair or the supply of repair parts. We define a best practice as a strategy or tactic employed by an activity experiencing short AWP delays or a tactic that improved supply support to an activity's customers. In some cases, we identified a potential process improvement as a best business practice if it would shorten AWP delays. To identify best practices, we visited public depots in each military service, commercial airline repair activities, private-sector firms repairing aviation components, and DoD wholesale suppliers of aviation repair parts.

We first propose that the military services adopt a new, common set of AWP metrics that would provide for the comprehensive reporting of AWP delays. This approach is a commercial best practice; private-sector firms rely on comprehensive reporting and management of AWP delays in their negotiations with customers on repair turnaround times. In addition, the services should record AWP costs separately instead of aggregating them in existing depot cost categories. This tracking would provide a means to gauge the financial significance of AWP delays and the cost-effectiveness of initiatives to reduce them.

Based on our research on the best business practices, we also recommend the following two-point approach to reduce AWP delays in the Department:

- Improve local retail parts availability by:
  - Replacing days-of-supply level-setting techniques with economic order quantity (EOQ) and variable safety level (VSL) setting techniques.
  - Replacing rules to stock an item based solely on demand frequency with rules based on demand frequency, expected order and shipping times (OSTs), and unit price.
  - Exploring alternatives, such as multiple models and ABC forecasting, to improve local forecasting of parts demand.

- Increasing inventory levels to achieve support goals comparable to goals of private-sector repair facilities, and using ABC inventory control to assign goals.

- Exploring ways to level or set the workload for components with expensive parts to help stabilize the demand and improve the efficiency and effectiveness of their levels.

- Improve wholesale availability by:

  - Adopting acquisition practices, such as head-start reorder points, corporate contracts with multiple sourcing, and contract clauses that emphasize performance, to reduce item lead-times and develop long-term sources of supply.

  - Studying how peak demand can be used to compute more effective and efficient levels for low demand frequency parts.

  - Incorporating in the wholesale forecasts for parts depot demand projections based on repair BOMs and a depot's projected overhaul and repair programs.

  - Reviewing military service and DLA procedures for keeping item coding current to reduce instances of rejected depot requisitions.

REPORT ORGANIZATION

The remainder of this report is organized as follows:

- *Chapter 2* documents our analysis of AWP frequency and duration.

- *Chapter 3* documents our analysis of AWP costs. It shows the costs and gives values based on collected samples.

- *Chapter 4* presents our analysis of the impacts of AWP on depot effectiveness and weapon system readiness.

- *Chapter 5* presents our analysis of local retail supply support and actions that can improve it.

- *Chapter 6* presents our analysis of wholesale parts availability and actions that can improve it.

- *Chapter 7* examines parts support at private-sector repair facilities and describes how the Department can implement their best practices.

- The appendixes contain supplemental information on AWP costs and activities affecting AWP delays.
  - *Appendix A* addresses actions to overcome AWP situations and their costs.
  - *Appendix B* discusses activities that are not presented in Chapter 5 but affect local retail parts availability.
  - *Appendix C* describes activities that are not discussed in Chapter 6 but affect wholesale parts availability.
  - *Appendix D* discusses topics in requisition processing as they relate to maintenance depots.
  - *Appendix E* lists the abbreviations used in the report.

Chapter 2
AWP Frequency and Duration

Depot commanders consider AWP to be one of their major problems, if not their number one problem. To verify their contention, we quantified the size of the problem by examining AWP frequency and duration data.

- *Frequency*. Frequency refers to how often AWP delays occur, and we measured it as the percent of repairs that have an AWP delay.
- *Duration*. Duration refers to how long AWP delays last, and we measured it as the average of all recorded AWP delays (in days).

An AWP delay occurs when an artisan does not have a part immediately available to repair an end item. However, Defense maintenance depots do not record an AWP condition if the part can be obtained from the supply system within a reasonable amount of time.

Each military service records AWP occurrences differently. No uniform, comprehensive database furnishes DoD-wide measures of AWP frequency and duration. Consequently, to quantify the size of the problem, we used data collected by the service AWP systems.

This chapter discusses how the Army, Navy, and Air Force identify and report the AWP delays that they consider significant.[1] It also presents measurements that we compiled on AWP frequency and duration from service data. Because the military services record delays differently, no comparisons between service measurements should be made.

ARMY

To observe how the Army monitors AWP delays in aviation and combat vehicle maintenance, we visited the Army's aviation depot at Corpus Christi, Texas; its combat vehicle depot at Anniston, Alabama; and its Industrial Operations Center (IOC) at Rock Island, Illinois. While we were conducting our study, the Army was transferring the management of its depots from the IOC to its wholesale managers. For example, management of the Army's electronics depot at Tobyhanna, Pennsylvania, was assigned to the Communication and Electronics Command.

[1] At the start of this study, our task was to focus on aviation maintenance, and we excluded the Marine Corps because Marine Corps aviation is under the Navy. Later, we added maintenance of Army combat vehicles to provide another category of logistics support.

System for Identification and Management

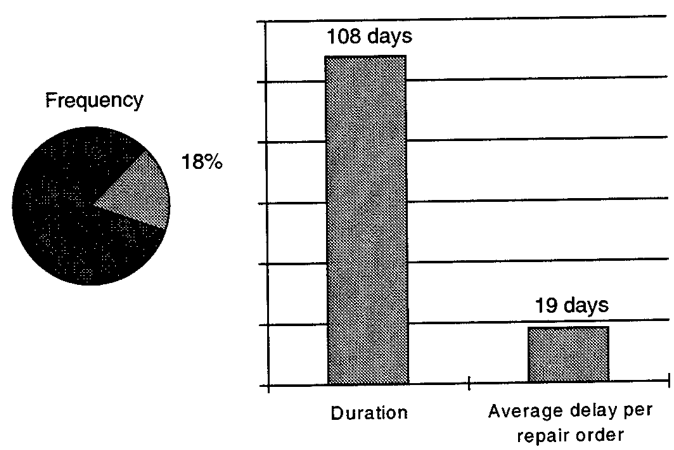
The Army monitors parts problems in its Reactive System's Critical Maintenance Repair Parts (CMRP) module. A record is added to the CMRP when the lack of a repair part has caused or will cause the depot to use costly workarounds to prevent a line stoppage. Records are put in CMRP for the following situations:

- *Category 1*—30 days have elapsed and the item can no longer be repaired by the work center. (This category is a work stoppage, the worst result of an AWP incident.)
- *Category 2*—Production stoppage is imminent within 30 days because parts are not available.
- *Category 3*—Production stoppage is imminent within 60 days because parts are not available.
- *Category 4*—A work center is using a workaround.

Measures

Using a sample of CMRP data for Anniston and Corpus Christi Army Depots (ADs) for fiscal year (FY) 1998, we compiled the duration measures in Figure 2-1. The frequency of 18 percent was provided by IOC and represents the percent of job orders with parts in CMRP.

Figure 2-1. Army AWP Frequency and Duration

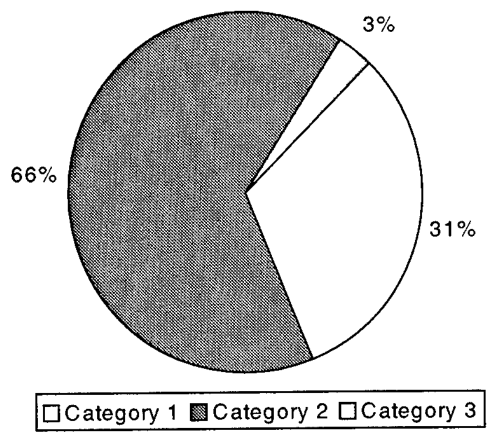


The duration measure of 108 days is the average days to resolve a delay. The final measure of 19 days is the average delay per repair order and is the product of the duration of 108 days and the frequency of 18 percent. These times support the view that AWP delays in Army maintenance are a significant problem that reduce the depot capability to make timely and responsive repairs.

CMRP Category Data

Job orders in the CMRP sample are divided into categories—Category 4 was not represented in the sample—in Figure 2-2.

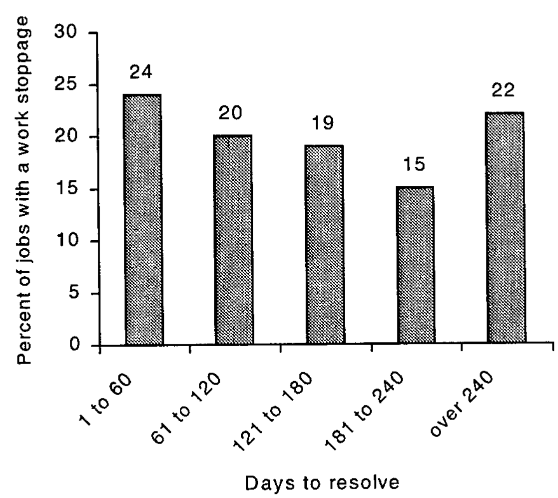
Figure 2-2. CMRP Categories



CMRP Category 1 AWP Times

Figure 2-3 depicts the distribution of AWP days for Category 1 items, which have the most negative AWP impact. A high percent of items is in the group with the longest AWP times.

Figure 2-3. Army Times to Resolve Parts Problems



Navy

To observe how the Navy monitors AWP delays in aviation maintenance, we visited the Navy's aviation depots at Cherry Point, North Carolina, and Jacksonville,

Florida, and the Naval Inventory Control Point (NAVICP) at Philadelphia, Pennsylvania.

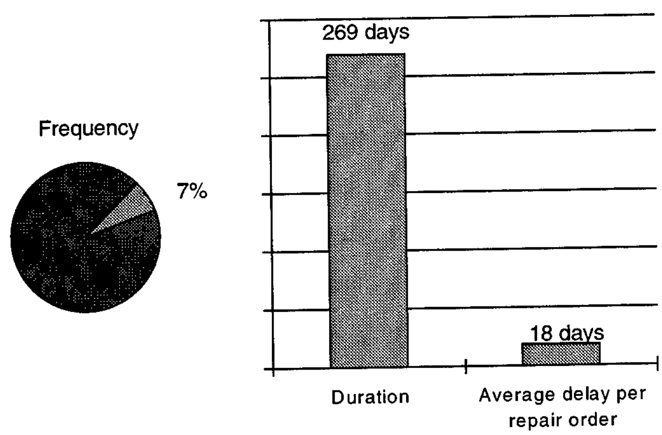
System for Identification and Management

The Navy monitors AWP problems in its "G" condition management system, referred to as the GMAN system. An AWP condition occurs when the expected delay in obtaining a part is greater than 45 days. When the condition occurs, the end item being repaired is set aside and put into condition code *G* until the required parts arrive. GMAN applies to naval aviation DLR items and excludes parts for engines and whole aircraft.

Measures

Using GMAN data, we compiled AWP frequency and duration statistics shown in Figure 2-4.

Figure 2-4. Navy AWP Frequency and Duration



The frequency of 7 percent is the percent of job orders with *G* time. The measure understates AWP conditions because it excludes short-term AWP delays and instances where the Navy does not induct an end item into repair because parts are not available. (See Chapter 3 for more information on the second exclusion.)

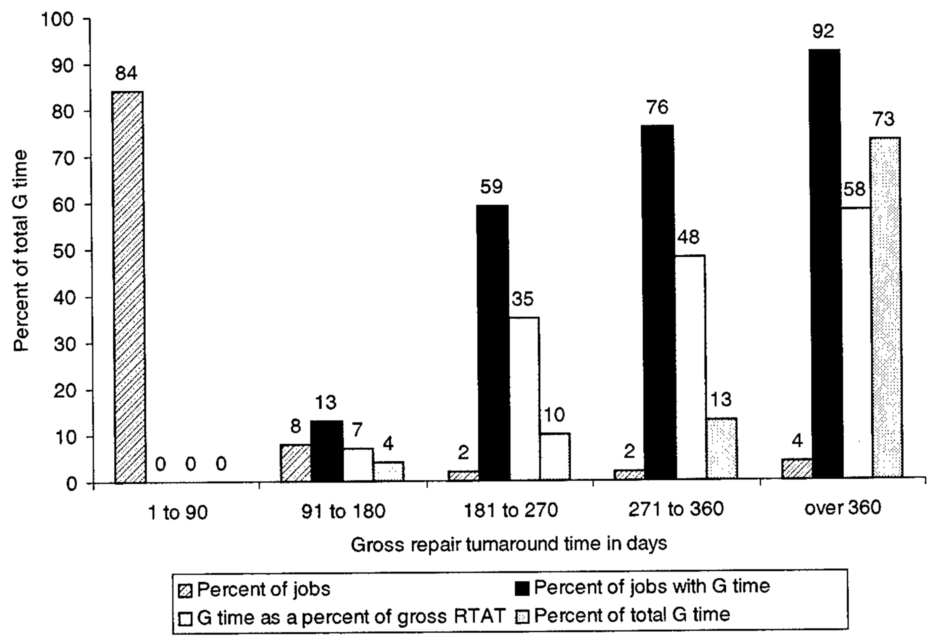
The duration of 269 days is the mean *G* time for the GMAN sample. The final measure of 18 days for the average delay per repair is the product of the duration of 269 days and the frequency of 7 percent.[2]

[2] All measures are rounded to the nearest integer.

SPECIAL MEASURES ON *G* TIMES FOR CATEGORIES OF REPAIR TIMES

We reviewed *G* times for jobs in several categories of gross repair turnaround times (RTAT) in GMAN data. Gross RTAT is the actual observed time from the start to finish of a repair. Figure 2-5 shows four measures—percent of jobs, percent of jobs with *G* time, *G* time as a percent of gross RTAT, and percent of total *G* time—for the RTAT categories we selected.

Figure 2-5. AWP and Gross Depot Repair Time



The first column in Figure 2-5 is the percent of jobs in each category. The majority of jobs are completed within 90 days. The measures of *G* time indicate that most jobs do not experience AWP conditions. This result may stem from the criteria that the Navy uses to put end items in *G* condition, namely, the expected delay waiting for a part is more than 45 days.

The second column in Figure 2-5 is the percent of jobs with *G* time. Although the overall percent, which is not shown in Figure 2-5, is 7 percent, the category percentages increase from 0 to 92 percent as gross repair time climbs.

The third column is the percent of total repair time that is *G* time. This measure also increases as the overall turnaround times increase. For the category with times more than 360 days, more than half the observed repair cycle is AWP time.

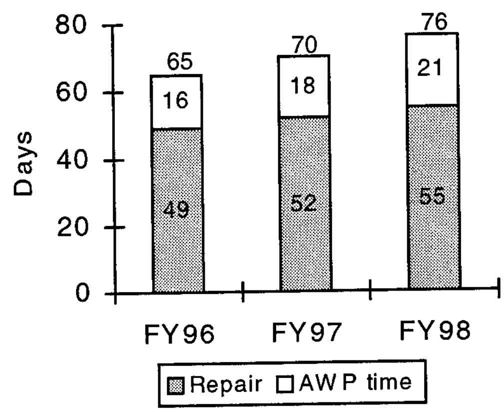
The final column addresses the contribution of each time category to overall *G* time. As might be expected, the highest contributor to *G* time is the category with times more than 360 days. The category with the most jobs (i.e., 1 to 90 days) makes almost no contribution to overall *G* time.

Because the Navy does not capture data on brief AWP occurrences, the measures in Figure 2-5 are biased. However, they clearly show that many Navy repairs have long *G* times.

Measures Over Time

We were able to collect 2.5 years of GMAN data that allowed us to look at AWP delays over time. Figure 2-6 shows how AWP times have increased.

Figure 2-6. Average Repair and AWP (Days)



Because GMAN routinely includes AWP delays less than 45 days in "repair time" rather than "AWP time," a reasonable conclusion is that at least part of the increase in repair times shown in Figure 2-6 is due to increasing AWP delays that are less than 45 days.

Air Force

To observe how the Air Force monitors AWP, we visited Headquarters Air Force Materiel Command and the Air Force's Warner Robins and Oklahoma City Air Logistics Centers (ALCs) in Georgia and Oklahoma, respectively.

System for Identification and Management

The Air Force monitors AWP with its Exchangeables Production System (EPS). Not all AWP occurrences are recorded in EPS. In general, an AWP problem is recorded when the expected delay in obtaining a part is greater than 10 days. However, each shop also has the flexibility to decide when to record an AWP condition. Normally, if the shop expects to receive the part within 2 weeks, it does not record the condition.

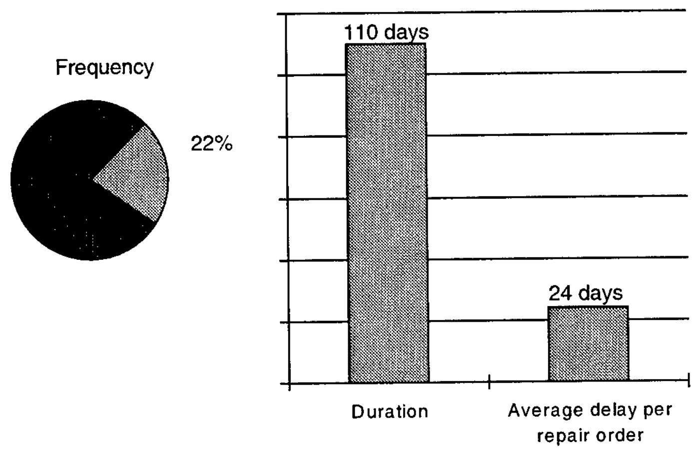
Like GMAN, EPS applies to DLR items and excludes parts for engines and whole aircraft. We reviewed EPS summaries of work-in-progress items in the Warner

Robins avionics shop for repair. This sample differs from our Army and Navy samples that were historical records of closed repairs.

Measures

From the EPS data, we compiled the measures in Figure 2-7.

Figure 2-7. Air Force AWP Frequency and Duration



To derive a frequency of 22 percent, we used the number of job orders that were currently AWP or AWP in their maintenance cycle. However, this measure may not accurately portray AWP conditions; some may be overstated. In addition, others may be understated because the measure does not include short-term informal or unofficial AWP conditions, and it does not consider the flexibility that shops have in delaying induction because parts are not available.

The frequency measure can also overstate the delays because job orders that have long AWP times receive extra weight. (For open repairs, AWP occurrences are weighted by the length of time repairs are open. A job order with a short AWP time has a lower probability of being in our sample than a job order with a long AWP time.)

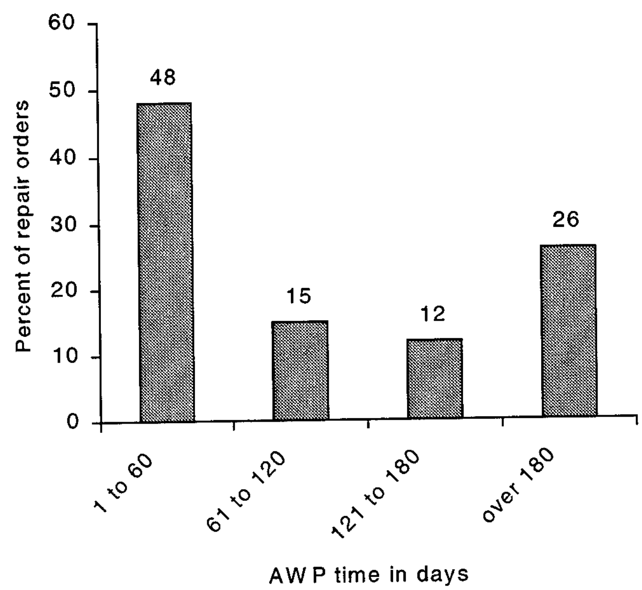
The duration of 110 days represents the mean AWP time for DLR items in work, those designated AWP, and those formally designated AWP that are not yet scheduled for reinduction (code "FWP"). The measure understates the mean time because current AWP items are open and have long times. Because the Air Force has the lowest time threshold for reporting AWP conditions, shorter AWP delays are included in its duration measure, making it appear to be the smallest of the services.

The final measure of 24 days combines the frequency and duration measures to determine the average AWP delay for all repair orders.

Air Force AWP Time Distribution

Using our Warner Robins sample, we also compiled measures of the time distribution for AWP conditions. Figure 2-8 shows the percent of items in selected time intervals. As expected, the percent of repairs with short AWP times is larger than that of the other services. However, like the other services, the Air Force has a large amount of repairs with long AWP times.

Figure 2-8. Time Distribution of Air Force Repairs with AWP



Summary of Findings

We found the following:

- All military services contend that AWP is a major inhibitor to depot maintenance.
- All military services have systems for tracking AWP, and each service collects a full range of measures on AWP delays. However, they do not have similar systems or common metrics.
- AWP delays are a significant problem for depot maintenance in each military service. They add between 18 and 24 days to the average repair cycle time for items. These averages are based on average frequencies from 7 to 22 percent and average durations from 108 to 269 days. All maintenance depots experience many long AWP delays (26 to 58 percent of AWP conditions last more than 180 days).

- The AWP measures collected by the services
  - differ in content and, therefore, do not allow for comparisons by service depot;
  - are often constrained by minimum time restrictions; that is, AWP conditions that do not exceed set time limits are excluded; and
  - do not generally distinguish AWP conditions that are maintenance line stoppers, work stoppages, or nonwork stoppages, or involve critical items.

CONCLUSIONS AND RECOMMENDATION

We conclude that AWP delays are not rare or brief. We also conclude that current service AWP measures are not adequate; they are not complete and do not permit comparisons. To overcome these deficiencies, we recommend that the military services develop a set of common AWP metrics. The metrics would be the frequency and duration of AWP conditions without minimum time restrictions; that is, all AWP conditions would be counted until they end. In addition, an AWP condition should be categorized by severity or criticality in a manner similar as the one the Army uses. Metrics would provide the following:

- All the information about AWP conditions needed by service logistics managers
- Information to aid maintenance managers and suppliers (e.g., DLA) in identifying where they need to improve parts support
- A mechanism for all maintenance managers to track progress in their efforts for reducing AWP conditions.

Chapter 3
Financial Impacts of AWP Delays

AWP delays increase the cost of maintenance and inventory. Generally, the increases are not identified separately but are absorbed in the overall costs of repair and inventory. Consequently, we were not able to quantify fully the financial impacts of AWP delays. This chapter identifies costs that are increased by AWP delays and presents a limited assessment on the value of some of the increases.

IMPACT ON MAINTENANCE COSTS

Maintenance depots work on a pay-for-service basis. When a depot returns a repaired end item to a customer, revenue is transferred to the depot from the funds that the customer obligated to do the work. The revenue is intended to cover all costs incurred by the depot in repairing the end item.

The cost to repair an end item consists of the following four categories—AWP delays can increase the costs of each category:

- *Direct labor.* Direct labor costs were 23 percent of the total cost in FY97 for the Army, Navy, and Air Force.
- *Materiels.* Materiel costs were 37 percent.
- *Indirect labor.* Indirect labor costs were 30 percent.
- *General and administrative (G&A) costs.* G&A costs were the remaining 10 percent.

How AWP Disrupts Work

When an end item is inducted into maintenance, time and expenses charged to the associated job order start to accumulate. As a maintainer makes repairs, he or she obtains parts from bench stocks or local shop inventories if the parts are in stock. If they are not in stock, the maintainer requests them from the depot's central supply (if different from the local shop inventory), a regional supply activity (if one exists), or a Defense or commercial source of supply.

While waiting for a part, a maintainer will do one of the following:

- Continue to work on another component of the end item that needs repair.
- Temporarily set the end item aside in the work area and work on another end item.
- Stop work on the end item and store it until parts arrive.

The last action is the most significant because it disrupts work and increases costs.

Cost Implications of a Work Stoppage

The costs of a work stoppage are the following:

- The cost to set aside the end item as AWP
- The cost to overcome the end item's AWP condition
- The cost to store the AWP end item until parts arrive
- The cost to schedule and induct another end item if one is inducted to fill the requirement
- The cost to reschedule an end item that was previously AWP
- The cost to rework time-sensitive parts if the associated AWP time is long.

Maintainers, schedulers, and warehouse personnel generate the costs. The costs are aggregated into the direct and indirect labor costs for repairing the end item and are not separated from other labor costs associated with the repair. As a result, assigning an exact value to a cost is practically impossible. To overcome this problem, we relied on examples to size the costs. However, we were only able to obtain examples of the costs of overcoming an AWP problem, which is the largest of the cost categories.[1]

[1] An engineering standards analysis is needed to determine the values of these costs, which is beyond the scope of this study.

EFFORTS TO OVERCOME PARTS SHORTAGES AND THEIR COSTS

Although the measures in Chapter 2 reveal long AWP times, they would be much longer if depot maintenance personnel did not take extraordinary efforts to overcome parts shortages. The efforts and examples of their costs are as follows:

- Depot maintenance personnel assign or reassign high priorities to requisitions for AWP items. This action increases depot processing and transportation costs.
- Depot maintenance personnel employ expeditors to communicate their shortages to sources of supply (e.g., DLA item managers) to ensure that the shortages are being addressed and resolved. For one depot, we estimate a cost of $958,000 per year for expediting actions. For another, our estimate is more than $341,000 per year.
- Depot maintenance personnel remove parts from other items that are being repaired or that are in storage (i.e., cannibalize parts). The cost of cannibalizations at one depot was $1.2 million per year. (This estimate is low because the cost of most cannibalizations is not reported.)
- Depot maintenance personnel use their procurement shops to make local purchases. The cost of a local purchase at one depot was between $250 and $500 per action.
- Depot maintenance personnel use their production capabilities to manufacture parts.
- Depot maintenance personnel repair failed parts that are normally thrown away. We found a case where the cost of reclamation was 31 percent of the cost of a new item and another case where the cost was 76 percent. However, reclamation is only possible when parts that can be fixed are available. Consequently, in one case, because only a limited number of parts could be reclaimed, reclamation was only a partial solution to a parts shortage.
- Depot maintenance personnel seek parts from other maintenance activities.
- Depot maintenance personnel work with item engineers to establish substitutes for parts that are not available.

Appendix A contains more detailed information on the costs shown above.

Composite Cost Estimate

Because we had only limited estimates, we were not able to develop a composite AWP cost estimate.[2] One depot manager estimated that the elimination of AWP would improve production by 20 percent, which would cause a 17 percent reduction in nonmateriels production costs.[3] Seventeen percent of FY97 Army, Navy, and Air Force nonmateriels production cost for aviation and vehicle depots is $386 million. If the 17 percent were applied to Army, Navy, and Air Force FY97 nonmateriels production costs for all depots, the total would be $764 million. Although this result is based solely on expert opinion, it gives an idea of the impact of AWP delays on maintenance costs.

Other Financial Implications

Impact on Cost Reimbursement

As previously mentioned, when an end item is set aside as AWP, maintenance personnel may bring in another unserviceable end item to fulfill the customer's requirement. All expenditures for the first item are charged to it and are not transferred to the new item.

When parts arrive for the first item, the need to repair it may no longer exist. If the repair is not complete, the depot will not be able to recoup funds that were expended. For this reason, depots place former AWP end items ahead of other items when scheduling inductions to satisfy new repair requirements.

As previously mentioned, depots account for their costs in the charges they bill to customers for repaired materiel. If the level of former-AWP materiel awaiting induction becomes large, accounting is more difficult to accomplish and reimbursement will not match expenditures.

From our Warner Robins sample, we computed the percent of open records with a status of FWP (i.e., records for former-AWP items awaiting induction). FWP records were 11 percent of the total records. Navy GMAN also had 11 percent of its records as AWI (i.e., records for former-AWP items awaiting induction).

Impact on Customer Sales

For DLR items, customers normally pay only the cost of repair for a replacement item. If the cost of repair decreases, units pay less and can use the uncommitted funds for other expenses (e.g., more training).

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[2] At the start of our cost analysis, we planned to quantify all costs and estimate depot costs that can be attributed to AWP conditions. We found that no accounting system captures all AWP costs, so we had to rely on available examples.

[3] The 17 percent estimate results from the following simple analysis: if the elimination of AWP delays allows depots to increase production from 100 to 120 percent with no change in costs, the cost to perform the work without AWP delays is the ratio of 120 percent to 100 percent.

As we noted earlier, we cannot estimate the change in the cost of repair if AWP delays were reduced. If we used our previous estimate of 17 percent as the maximum reduction, a 50 percent reduction in AWP would reduce customer costs by 8.3 percent; a 25 percent reduction would result in a 4.2 percent reduction, and so on.[4]

IMPACT ON INVENTORY COSTS

As described in *The Depot Repair Cycle Process: Opportunities for Business Practice Improvement*, increases and decreases in repair cycle times can result in increases and decreases respectively in inventory and associated materiel costs.[5] Moreover, because storage costs are a function of the amount of stored inventory, increases or decreases, in turn, should increase or decrease storage costs. In the next two sections, we estimate the materiel and storage costs of AWP delays.

Materiel Cost Estimate for AWP Delays

HOW AWP DELAYS INCREASE DLR INVENTORIES

DLR items can be obtained from two sources—procurement and repair. The time that an unserviceable item is in the repair process is its repair cycle time. To cover demands for the item while unserviceable assets are in the repair process, an item manager maintains a level of inventory. The size of the inventory depends on the length of the repair cycle time—the longer it is, the larger the inventory.

The amount of the potential savings from reducing AWP times depends on the times included in repair cycle times. The military services have the following policies:[6]

- The Army includes AWP time in repair cycle time.
- The Navy uses a 95 to 150 percent rule that allows gross repair cycle times within limits to update the repair cycle time of record. (From our Navy sample, we estimate that this rule allows AWP times to be used in an update for 2 percent of the jobs or 36 percent of the jobs with AWP.)
- Air Force standards exclude AWP time.

[4] Because depot customers pay fixed prices for repairs, they would not immediately see a cost reduction with a reduction in AWP delays. However, because the depots periodically adjust their prices to reflect changes in their costs, customers would realize the reduction in their costs.

[5] Logistics Management Institute, *The Depot Repair Cycle Process: Opportunities for Business Practice Improvement*, Report LG406MR1, Kelvin K. Kiebler et al., May 1996.

[6] DoD policy in DoD Regulation 4140.1-R, *DoD Materiel Management Regulation*, May 1998, excludes AWP time from level-setting computations. The policy is based on the premise that an AWP delay is a rare and random event.

COMPUTING THE SAVINGS

To estimate the materiel costs of AWP, we relied on the measures in Chapter 2 of duration and frequency and on the Army and Navy FY98 stratification reports. Our estimate for potential inventory savings is the product of the average number of AWP days and the cost of 1 day of inventory. For the Navy, we adjusted the average number of AWP days because the Navy does not include all AWP conditions. We also made an adjustment because the Navy stratification report is based on a 60-day repair cycle time. Table 3-1 lists our estimates and the total.

Table 3-1. Inventory Savings Potential for Reducing AWP

Military service	Average AWP time (days)	Cost per day ($ million)	Savings potential ($ million)
Army	19.44	4.75	92
Navy	2.26	8.98	20
Air Force	N/A	N/A	0
Total			112

Inventory savings can only be realized through delayed procurements, which may take years to occur or may not occur for items where demand drops off.

Storage Cost Estimate for AWP Conditions

The $112 million in Table 3-1 represents inventory that is stored. A standard approach to determine the cost of storage is to multiply the value of the inventory by the storage cost rate (2 percent of the value of the inventory). Applying that computation, DoD would achieve annual savings of $2.2 million in storage costs if AWP conditions were eliminated.

CONCLUSIONS AND RECOMMENDATIONS

As a result of our analysis of financial impacts, we conclude the following:

- AWP delays increase the cost to repair an end item because of work stoppage costs, expediting costs, and workaround costs.
- Isolating those additional costs in the depot cost accounting system is not possible because the associated labor and materiel costs are aggregated into the general cost categories for repairing an end item.

- The additional costs cause the prices that DoD units pay for materiel to increase and prevent the depots from receiving full reimbursements.
- AWP delays increase DLR inventory costs, although the additional costs may not be as significant or recoverable as the additional maintenance costs.

If AWP delays constitute a major inhibitor to effective and efficient maintenance, the Department needs data to measure the potential payback from initiatives to reduce them. The data would not only be the frequency and duration metrics recommended in Chapter 2, but also data on AWP costs. Therefore, we recommend that the military services establish a program to collect costs associated with AWP delays.

Some AWP costs identified in this chapter would be too small to measure or would pose an onerous burden on maintainers if measured per incident. Therefore, we recommend that the military services initially develop a program that collects costs that are easily identified as AWP-related (e.g., cost of depot expeditors, costs of manufacturing parts, costs of over-induction). The services can extend the program to other costs as warranted.

Chapter 4

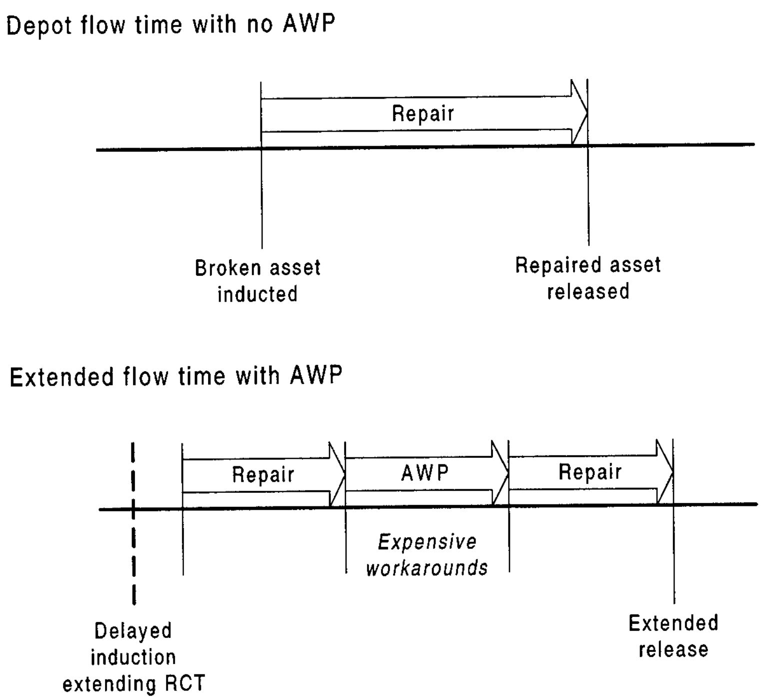
Operational Impacts of AWP Delays

AWP delays degrade depot effectiveness in scheduling and repairing end items needed by DoD forces. Unless offset, this degradation can reduce weapon system readiness.

IMPACTS ON DEPOT EFFECTIVENESS

Besides the financial impacts discussed in Chapter 3, AWP delays reduce the effectiveness of maintenance depots by delaying the induction of end items. They also lengthen depot flow times, thereby causing wide variances between expected and actual flow times (see Figure 4-1).

Figure 4-1. Depot Repair Time and AWP



Repair and Overhaul Process

The demand for DLR items comes from the need to replace failed items or establish an inventory to support a new customer mission. The former is recurring demand, and the latter is nonrecurring. DLR item managers generally build levels to

support recurring demand. When they issue stock from their levels to replace failed items, they receive the failed items in return.

DLR item managers have two sources of supply for ready-to-issue items. One is the depot repair process where unserviceable items are fixed and returned to the supply system. The other is the procurement process; it replaces assets that are condemned during maintenance or adds assets to meet new requirements.

The repair process starts when a depot receives a job order to schedule and induct unserviceable assets. It ends when the maintenance shop repairs the assets and returns them to the supply system in a ready-for-use condition.

The military services acquire major end items from commercial production. Once the items are acquired, managers of the items rely on the overhaul process as their source of supply. The following are the principal participants in the repair and overhaul process:

- Wholesale DLR item managers, who manage the stocking and issuing of assets to DoD customers and depend on the maintenance depots to repair unserviceable assets
- Weapon system and equipment managers, who manage major end items and depend on the maintenance depots to overhaul their assets
- Maintenance depots, which perform the required repair or overhaul and are a source of demand for repair parts
- Wholesale repair part item managers, who manage the stocking and issuing of parts used in the repair process to DoD customers, including major users, such as the maintenance depots.

Depot Scheduling and Induction Process

To ensure that levels of replacement items are not depleted, item managers generate and send repair orders to maintenance depots, which schedule and repair failed items. The goal of efficient and effective scheduling is to have the workload reflect as much as possible the current repair requirements of item managers. If the number of scheduled units is higher than required, the depot would be repairing surplus stock, thereby wasting resources on items that may not be issued in the near future. If the number of scheduled units is lower than required, customer requisitions may be backordered, and backordered requisitions hinder the ability of customers to carry out their assigned missions.

Two Approaches to Scheduling and Induction

DLR items are scheduled and inducted into maintenance in two ways. The first is level loading, where workload is scheduled and inducted by quarter. Normally,

quarterly scheduling involves negotiations between maintenance depots and wholesale managers, balancing the needs of the managers against the capabilities of the depots. After a schedule is prepared, the maintenance depot inducts end items to meet the schedule. The Army and Navy use this method.

The second method is based on need and criticality. At least weekly, the repair requirements of wholesale managers are ranked according to their need and criticality. For example, the Air Force ranks DLR items by their impact on weapon system readiness. The items with the highest rankings are inducted first. The Navy also uses this method for some items.

PARTS CHECKS

As previously noted, workload scheduling should always match item manager requirements. However, this objective is not always achieved. Shortages in parts, maintenance resources, or items to be fixed cause the amount of workload scheduled to be less than the amount required.

Not all depots conduct parts checks; but when they do, the checks are made before end items are scheduled or inducted. Depots, which use level loading, check parts before scheduling an item for repair. Depots that induct items according to need and criticality check for parts before induction.

If the lists of predicted parts used in the repair process are fairly reliable, parts checks are appropriate. They avoid the early expenditure of depot resources on the repair of assets that would have to wait for parts to be completed. However, in cases where predicted usage is not reliable, parts checks should not be made.

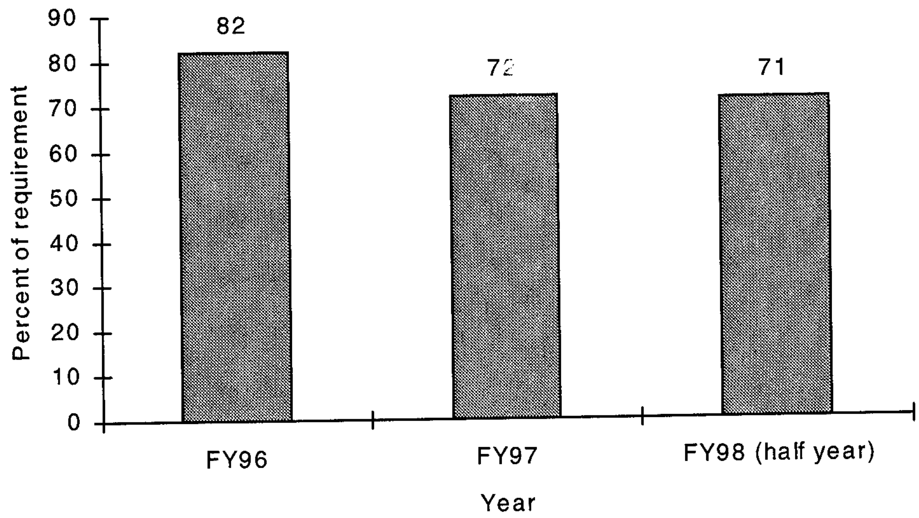
If the scheduling or induction of an end item is delayed by a parts check, that delay is an AWP delay.

IMPACT OF PARTS SHORTAGES ON SCHEDULING

Depot managers that use parts checks consider the differences between item manager requirements and the scheduled workload to be significant and increasing. One service provided historical data to confirm this fact (Figure 4-2).

Figure 4-2 demonstrates the significance of the problem and its increasing trend. If this problem continues, end item shortages will occur as needed items are not repaired. One depot we visited only inducted 42 percent of the quarterly requirement. Parts shortages caused 84 percent of the delayed inductions. The solution to this problem is not to eliminate parts checks but to reduce parts shortages that contribute to AWP delays.

Figure 4-2. Scheduled Repair as a Percent of Required Repairs



REPAIR SCHEDULES

If maintenance depots anticipate a parts shortage, they may over-induct assets to meet the repair requirement of the DLR item manager. The depots use the extra assets as an additional source of supply to cannibalize parts, particularly assets that are beyond repair. In addition to the associated cannibalization costs, over-induction involves additional time and money for processing the extra assets through repair. (Information on the magnitude and cost of over-induction is not available.)

Depot Flow Times

AWP delays extend depot flow times. In Chapter 2, we present measures of how much they extend times and, in Chapter 3, we address the financial impacts in terms of inventory costs. However, if a customer is waiting for an end item to be repaired, AWP delays extend the wait. The cost of that wait could be small or it could be significantly large. The next section of this chapter discusses how extended waits reduce readiness.

READINESS IMPACTS

AWP delays adversely affect readiness because they extend the time that weapon systems are nonoperational waiting for replacements for failed components. However, measures are not readily available that quantify how much readiness is adversely impacted by AWP delays. In fact, the negative impacts of depot AWP delays are often mitigated by workarounds (e.g., local cannibalization, robbing of wartime spares). The following subsections discuss how we used simulation to

measure the potential impacts of AWP delays on readiness if no workarounds were performed.

Testing Impact of AWP Delays on Air Force Aircraft Readiness

To gauge the potential impact of AWP delays on readiness, we tested the effect of varying lengths of AWP delays on aircraft availability. Aircraft availability is the expected proportion of aircraft available to fly. It is a function of the multi-echelon, multi-indenture supply chain that provides replacement end items to keep aircraft mission-capable. The Air Force sets aircraft availability goals for each aircraft type to compute readiness-based spares levels.

To conduct our analysis, we employed LMI's Aircraft Availability Model (AAM). The Air Force has used the AAM since the early 1980's to compute worldwide DLR item requirements and analyze the effects of policy changes. The AAM can also assess the aircraft availability resulting from a set of spares levels, repair times, and other supply chain parameters.

Our Approach

Initially, we selected DLR item data for several aircraft and their assigned aircraft availability goals. For our baseline, we allocated each DLR item the standard AAM requirements; that is, the depot and retail levels of spares needed to achieve the assigned aircraft availability goals.

For our alternatives, we added delays to the depot repair time of each DLR item while keeping other model variables constant. In this manner, we were able to simulate an AWP delay and measure its impact. Because we did not consider cannibalization and other actions that the supply chain might take to compensate for delays in depot repair times, our results may be viewed as "worst case."

Summary of Test Results

Table 4-1 shows our test results for seven lengths of AWP delay. The rows in Table 4-1 correspond to aircraft types, the columns to the number of days of AWP delay, and the number in each cell represents the estimated decrease in aircraft availability (from the aircraft type's availability goal) resulting from the delay. For example, if the E-8 goal for setting inventory levels is 90 percent, Table 4-1 shows that a delay of 20 or more days would reduce E-8 aircraft availability to 0. The aircraft are listed from highest to lowest by availability decreases with a 20-day delay (the delay closest to the 24-day delay computed in Chapter 2).

Table 4-1. Reduction in Aircraft Availability for AWP Delays

Aircraft type	AWP delays and reduction in aircraft availability (percent)						
	1 day	2 days	5 days	10 days	20 days	30 days	50 days
E-8	2	4	31	85	90	90	90
C-5	4	24	89	89	89	89	89
B-1	2	4	12	27	56	76	76
F-16	0	0	16	34	46	58	74
F-15	0	0	13	20	40	68	87
KC-135	0	0	2	11	35	57	78
B-52	0	0	4	12	35	55	72
H-53	1	2	5	11	28	46	74
A-10	0	0	2	5	12	19	36

The results show that AWP delays shorter than 20 days can also severely degrade aircraft availability. The severity of the readiness impact for 1- to 5-day AWP delays varies greatly by aircraft type, but delays of 50 days have an unacceptable effect on readiness for all types of aircraft.

Other Testing

A Navy-sponsored study for the F/A-18 found results similar to ours.[1] Specifically, the study found that a depot delay (which could be interpreted as an AWP delay) of 30 days more than the normal depot repair time resulted in an overall readiness rate of 60 percent. (This rate is absolute and not a decrease from a goal.) A depot delay of 60 days reduced the readiness rate to less than 50 percent, and a delay of 90 days brought the readiness rate below 40 percent. We expect the same result for any weapon system because a delay in the supply chain supporting a weapon system should degrade its readiness.

Why do readiness rates remain high when the military services are experiencing high levels of AWP delays? The answer is that workarounds, such as cannibalization, local purchase, local manufacture, and expedited parts delivery, offset AWP delays and mask the potentially severe readiness impacts of AWP delays.

The Center for Naval Analyses conducted an analysis of the effect of various supply chain parameters on readiness rates, also focusing on the F/A-18. The analysis found that full cannibalization improved the readiness rate by 30 percentage points or more. This finding suggests that cannibalization accounts for much of the difference between the dramatic decline in aircraft availability predicted by

[1] CACI, Inc., performed the analysis for the Navy. The analysis used the Navy's aircraft readiness model to consider the effects of wholesale delays of varying lengths on overall logistics response time (LRT) and readiness, but keeping spares levels and other supply chain parameters constant. It focused on one type of Navy aircraft, the F/A-18.

the AAM and the less severe effect of AWP on readiness experienced by the military services.

However, the ability of workarounds to offset AWP delays is not infinite; and no practical measure depicts the limits of workarounds to offset AWP delays. When the workarounds are exhausted, readiness degradation may be abrupt and serious.

Conclusions and Recommendation

As a result of our analysis of operational impacts, we conclude the following:

- AWP delays disrupt depot scheduling and induction.
- AWP delays extend depot flow times that are critical to an item manager's ability to support customers.
- Our tests of the impact of AWP delays on aircraft availability indicate that readiness for some weapon systems should be severely degraded by current levels of AWP delays. We believe we did not find evidence of severe degradation because elements of the supply chain supporting weapon systems are performing workarounds. The workarounds mask the effects on readiness, which may decline unexpectedly if the workarounds were no longer available.

In the chapters that follow, we explore ways that AWP delays can be reduced with changes to business practices at retail supply activities supporting depot maintenance and at sources of supply for parts.

Chapter 5
Parts Availability at DoD Maintenance Depots

This chapter examines retail parts availability at DoD maintenance depots. To emphasize the fact that we are focusing only on those retail inventories that are actually at the depots, we'll refer to them as local inventories and use the term local parts availability. In this chapter, we'll discuss the following topics:

- Importance and measurement of local parts availability
- Two recurring, systemic problems that cause parts not to be available locally and actions that can resolve them
- Nonrecurring activities that aggravate problems in making parts locally available
- Activities that reduce the problems in making parts available locally.

Importance of Local Parts Availability

Like any dynamic demand process, the repair process at maintenance depots poses a challenge to supporting supply systems. When repair parts are locally available or they can be obtained quickly from sources of supply, an extended AWP condition does not occur. However, when a part is not available locally, the possibility of an extended AWP condition exists.

The amount and time of backorders are important AWP metrics; together they define the average time a maintainer waits for a part. Typically, maintenance depots measure the number of backorders in terms of gross issue effectiveness or net issue effectiveness rates. Both rates are synonymous with fill rates or supply availability rates. They are defined as follows:

$$Gross\ Issue\ Effectiveness = \frac{Total\ Issues}{Total\ Demands} \times 100\% \qquad \text{[Eq. 5-1]}$$

$$Net\ Issue\ Effectiveness = \frac{Total\ Issues\ for\ Stocked\ Parts}{Total\ Demands\ for\ Stocked\ Parts} \times 100\%. \qquad \text{[Eq. 5-2]}$$

Because nonstocked parts should not be available for issue, total issues should equal the total issues for stocked parts. Consequently, net effectiveness should be higher than gross effectiveness because the denominator is smaller.

Inventory Effectiveness Measures

To gauge their supply performance, depots have gross or net issue effectiveness goals. Table 5-1 lists local issue effectiveness measurements for the goals of four depots we visited. Except in the case of the gross effectiveness for depot 4, average monthly performance was below the desired goal. However, for that depot, net effectiveness performance was below its goal.

Table 5-1. Depot Gross and Net Issue Effectiveness Measures

Depot	Metric	Goal (%)	Average (%)	Monthly maximum (%)	Monthly minimum (%)
1	Gross	88.0	72.4	76.6	69.9
2	Gross	70.0	46.9	52.4	40.6
	Net	90.0	79.5	90.1	65.2
3	Net	85.0	80.1	85.0	75.0
4	Gross	70.0	77.2	81.0	73.0
	Net	85.0	83.0	86.9	79.0

Impact of Not Meeting Local Performance Goals

Table 5-2 shows the increased time that artisans wait for parts because depots are not meeting their gross issue effectiveness goals. To construct Table 5-2, we completed the following steps:

- Using DLA requisition data, we computed a 67.4 fill rate for high-priority requisitions from service maintenance depots.[1]
- For the requisitions, we computed an average time of 12 days from the date of requisition to the date shipped for immediate fills and an average time of 406 days for backordered requisitions.
- We added 3 days for CONUS intransit time to determine average times for immediate and backordered issues.
- We used 70 percent local gross issue effectiveness as a baseline goal and 65.5 percent (the average of our four depots) as the actual performance for that goal.

[1] Demands not filled locally are backordered and requisitioned with a high priority. Low-priority requisitions are made for local stock replenishments.

Table 5-2. Time Difference Between Baseline Retail Performance at Goal and at Actual Performance

Parts supply chain activity	Metric	Baseline	Actual performance
Wholesaler	Percent of immediate fills (f_w)	67.4	67.4
Wholesaler	Days to receive immediate fills (t_w)	15.0	15.0
Wholesaler	Percent of backorders ($1\text{-}f_w$)	32.6	32.6
Wholesaler	Days to receive backordered materiel (t_b)	409.0	409.0
Local retailer	Percent of immediate fills (f_l)	70.0	65.5
Maintainer	Average days to receive part	43.0	50.0

Note: Time = $(1\text{-}f_l) \times (f_w\, t_w + [1\text{-}f_w] \times t_b)$.

Although our approach in constructing Table 5-2 is simplistic and our results are estimates, they illustrate the importance of meeting local performance goals.

Impact of Not Having Local Inventories

Rapid, low-cost transportation is not a substitute for local inventories. As illustrated in Table 5-3, local inventories are the first line of support for maintenance.[2] Even if the time to receive immediate fills is reduced to 1 day, the response time without local inventories would increase from 43 to 134 days.[3]

Table 5-3. Response Time With and Without Local Inventories

Parts supply chain activity	Metric	Baseline	No local inventory
Wholesaler	Percent of immediate fills (f_w)	67.4	67.4
Wholesaler	Days to receive immediate fills (t_w)	15.0	15.0
Wholesaler	Percent of backorders ($1\text{-}f_w$)	32.6	32.6
Wholesaler	Days to receive backordered materiel (t_b)	409.0	409.0
Local retailer	Percent of immediate fills (f_l)	70.0	0.0
Maintainer	Average days to receive part	43.0	143.0

Note: Time = $(1\text{-}f_l) \times (f_w\, t_w + [1\text{-}f_w] \times t_b)$.

The importance of local inventories to customer support does not diminish the importance of initiatives to improve source-of-supply responses to the depots. Initiatives, such as virtual prime vendor, lead-time reduction, and shorter transportation time standards, improve source-of-supply performance. However, improvements should not be considered replacements for local supply; rather, they are enhancements.

[2] Table 5-3 duplicates Table 5-2 except local issue effectiveness is zero where no local inventory exists.

[3] Achieving our baseline 43-day response time without local inventories requires an alternative, such as increasing wholesale availability to 85 percent and reducing immediate time to 1 day and backorder time to 277 days.

General Reasons Why Parts Are Not Available Locally

The principal reasons why parts are not available locally are difficulties in forecasting the need for parts and difficulties in stocking spare parts to satisfy that need. Both problem areas are discussed in the following two sections. Other activities that aggravate or improve local parts availability are discussed in Appendix B.

FORECASTING LOCAL REPAIR PARTS NEEDS

Forecasting future demand for repair parts is not an easy task for the following reasons:

- Planned workloads for end items to be repaired can change.
- The parts needed to repair individual end items can differ.
- Some repair parts have no forecasted requirement because of their demonstrated high reliability or because they are only needed as part of a one-time modification.
- The models that produce forecasts are inaccurate. They do not have all relevant data (e.g., inaccurate BOMs) or they are based on past events and not the processes that generate failure.
- Depot demand forecasts usually deal with service-sponsored component repair and may not include other potential sources of demand (e.g., major end item overhaul, interservice support, support to other government agencies, and foreign military sales).

All reasons contribute to the error in forecasting demand for repair parts.

Methods of Forecasting

Historically, DoD maintenance depots have used moving averages to forecast repair parts requirements. Moving averages and single smoothing are two simple forecasting methods commonly used to forecast demand. Both methods are referred to as "time series" methods because they rely on past observations of demand (e.g., last quarter's demand) to forecast future demand.

More complex time series methods look at trend, seasonality, and other cyclic patterns in the demand stream. Although all these methods consider variability of demand, they work best when characteristics of demand variance are known.

If high variability in the numbers of repairs is causing high variability in repair part demand, program-based forecasting may be an alternative to time series analysis. Instead of being based on historical demand, it relies on the projected

repair program for end item and replacement estimates for repair parts to generate a forecast. For example, if the estimated replacement rate for part A is 50 percent and two end items that use part A are being repaired, then the expected usage is one (i.e., $0.5 \times 2 = 1$).

Analysis of Forecast Error

We were not able to collect any measurements of parts forecast error at depots, and we did not have sufficient data to construct any historical measurements. Therefore, to gauge how demand and program variability affect forecast accuracy, we conducted a simulation analysis of a simple hypothetical case that involved one end item with two potential repair parts.

In our analysis, we used statistical distributions to represent program and demand variability. The scenarios we tested consisted of different combinations of no variance and limited statistical variances in demand, program, or both. We excluded tests of long-term increasing and decreasing trends in program. Consequently, the levels of forecast error produced by the simulation are lower than they would have been if such trends were included, particularly the levels of error for exponential smoothing and moving average.

Because we used simulation to evaluate the levels of error for different forecasting approaches, we ran multiple trials for each scenario to develop a range for the potential forecast error. The range was based on a 95 percent confidence interval (i.e., we can express with 95 percent confidence that the actual error would be in the given range). Our analysis is summarized in Table 5-4. (The rows give the ranges of error for each method of forecasting while the columns list the ranges of error for each scenario. The level of error is represented as a percent of the forecasted demand.)

Table 5-4. Percent of Relative Levels of Depot Demand Forecast Error (95 Percent Confidence Intervals)

Forecast	No variance	Variance in program	Variance in demand	Both program and demand variance
Program-based	0	32 to 71	131 to 253	140 to 280
Moving average	0	33 to 41	138 to 258	98 to 231
Exponential smoothing	0	24 to 28	135 to 255	75 to 145

Although the results are based on simulation, they demonstrate the following:

- No demand or program variability results in no forecasting error (column 2) regardless of the forecasting method.
- However, if demand and program variability exist, they can cause high levels of error (columns 3, 4, and 5) regardless of the forecasting method.

- The combination of demand and program variability can affect program-based forecasting more than the other two ad hoc methods (moving average and exponential smoothing) because it relies on the stability of both to produce an accurate forecast.[4]

The results are significant because high levels of error, resulting from forecasting too high or too low, negatively affect inventory control. When forecasts are too high, suppliers acquire and carry levels of inventory that are more than required. When forecasts are too low, suppliers may not carry enough inventories to satisfy customer demand at a desired level of performance.

Efforts to Reduce Forecast Error

The highest levels of forecast error occur when the mean demand and demand variance for a part are unknown. Accurate BOMs provide for better estimates of mean demand that help reduce forecast error. Maintenance depots have been rigorously reviewing their BOMs in anticipation of installing Maintenance Requirements Planning II or similar software programs because they comprehend the cost and performance implications of inaccurate BOMs. These programs forecast part requirements based on the program schedule and the revised usage factors.

In Chapter 7, we discuss potential process improvements in parts forecasting that we observed in the private sector.

LOCAL RULES FOR STOCKING REPAIR PARTS

Local stockage rules consist of range rules (i.e., rules on when an item should be stocked) and depth rules (i.e., rules on how much stock should be maintained). If the rules are ineffective in satisfying customer demand (as measured by issue effectiveness) or inefficient in distributing funds to stock levels, they cause AWP delays.

Range Rules

We found that the range rules typically used by a maintenance depot involve the number of demands in a period (e.g., 6 demands in 6 months). Because of demand and program variability, the effectiveness and efficiency of the rules are questionable. A more appropriate set of rules would consider the expected OST to receive materiel from the source of supply and the cost of stocking or not stocking the part. Table 5-5 illustrates the stockage preferences that should be given for demand, price, and OST. Preference should be given to items with high demand

[4] These results do not demonstrate that exponential smoothing and moving average outperform program-based forecasting because our testing only considered a level program. If the repair program had an increasing or decreasing trend, program-based forecasting would immediately recognize that trend, while the exponential smoothing and moving average would not.

as current rules do. However, unlike current rules, preference should also be given to items with long OST times or low unit prices.

Table 5-5. Stockage Preferences of New Range Rules

Case	Demand		Price		OST		Stockage preference
	Item 1	Item 2	Item 1	Item 2	Item 1	Item 2	
1	Low	High	Same		Same		Item 2
2	Same		Low	High	Same		Item 1
3	Same		Same		Short	Long	Item 2

Depth Rules

Levels that are generally used by on-site parts suppliers at maintenance depots include the following:

- An OST level to cover demand while stock is being replenished from the source of supply
- A safety level to cover variances in demand and OST while stock is being replenished from the source of supply
- A reorder point indicating when to reorder stock from the source of supply (normally, the sum of the OST and safety levels or a numeric level)
- An order quantity indicating how much to order when the level of assets reaches the reorder point
- A requisitioning objective indicating the quantity to order (normally, the sum of the reorder point and the order quantity or a numeric level).

Computational Techniques

DoD maintenance depots, similar to other DoD retail supply activities, compute OST levels as the product of the OST in days times the demand per day. However, they use a wide range of techniques for computing order and safety levels.

The techniques range from simple days or months of supply computations to complex EOQ and VSL computations. In inventory control theory, simple models, such as months of supply, are not considered optimal because they increase the inventory costs of attaining a desirable level of support and provide little assurance that the desirable support goal will be attained. For these reasons, DoD retail supply policy requires the use of EOQ and VSLs.[5]

[5] Department of Defense, *DoD Materiel Management Regulation*, DoD 4140.1-R, May 1998, pp. 48–49.

Testing the Efficiency and Effectiveness of Different Techniques

Using large samples of items requisitioned by three service depots, we tested the effectiveness and efficiency of several sets of depth rules. Specifically, for each rule, we looked at gross issue effectiveness (GIE), previously defined in Equation 5-1, and cost per dollar demand (C/$D) defined in the following equation:

$$Cost\ Per\ Dollar\ Demand = \frac{Total\ Cost}{Total\ Dollar\ Value\ of\ Demand} \quad \text{[Eq. 5-3]}$$

In Equation 5-3, the total cost is the sum of the following costs:

- Inventory investment
- Cost of stocking items
- Cost to replenish the inventory
- Cost to hold the inventory
- Cost of backorders consisting of the cost of ordering from the source of supply and the cost of expediting delivery.

To perform our tests, we used an inventory analyzer (i.e., a model composed of mathematical equations replicating the performance of an inventory system). We tried to gear the analyzer to reflect the current performance statistics we had on the depots. However, because of the assumptions in the analyzer and because exact replication of performance is not possible, the performance and cost values put out from the analyzer are not exact. They show relative differences between alternatives, not absolute differences.

Order Quantity Test Results

Table 5-6 presents test results for several order quantity computations (no safety level). They demonstrate that smaller order quantities reduce both cost and performance (months-of-supply columns). They also demonstrate that, at least in the case of no safety level, an EOQ computation provides equal or better performance at equal or lower cost than a months-of-supply computation.

Table 5-6. Varying Order Quantities with Zero Safety Level

Depot	Metric	Months of supply				EOQ
		12	6	3	1	
Anniston	GIE	94.9%	91.6%	86.4%	75.0%	77.8%
	C/$D	50 cents	28 cents	18 cents	15 cents	12 cents
Cherry Point	GIE	94.2%	90.9%	85.9%	75.0%	75.8%
	C/$D	44 cents	23 cents	13 cents	8 cents	8 cents
Oklahoma City	GIE	94.7%	91.1%	85.9%	75.0%	75.0%
	C/$D	49 cents	27 cents	16 cents	12 cents	11 cents

Fixed Safety Level Results

Table 5-7 presents test results for different months-of-supply safety level quantity computations (and an EOQ). Months-of-supply safety levels are called *fixed levels* because every item receives the same portion of demand as its level. In Table 5-7, the decline and subsequent increase in the cost per dollar demand stems from the fact that as the investment in safety level increases, the number and dollars of backorders decrease; however, at some point the investment increase is greater than the backorder dollar savings.

Table 5-7. Varying Fixed Safety Level Quantities with EOQ

	Metric	EOQ with no safety level	EOQ with one-half month safety level	EOQ with 1 month safety level
Anniston	GIE	77.8%	90.2%	93.6%
	C/$D	12 cents	10 cents	13 cents
Cherry Point	GIE	75.8%	85.7%	89.8%
	C/$D	8 cents	10 cents	14 cents
Oklahoma City	GIE	75.0%	85.2%	89.4%
	C/$D	11 cents	12 cents	15 cents

Variable Safety Level Results

The two main computations of a VSL are one where each item is given a desired level of protection against backorders and one where all items are collectively given a desired level of protection. Because repair requires that 100 percent of all failed parts be replaced, the availability of each part is important. Therefore, we selected the first computation that has a target availability for each stocked item.

Table 5-8 presents test results for different variable safety level quantity computations (and an EOQ).

Table 5-8. Varying Variable Safety Level Quantities with EOQ

	Metric	EOQ with 75% protection	EOQ with 85% protection	EOQ with 95% protection
Anniston	GIE	82.1%	87.1%	94.0%
	C/$D	15 cents	18 cents	26 cents
Cherry Point	GIE	83.3%	87.4%	93.5%
	C/$D	17 cents	26 cents	45 cents
Oklahoma City	GIE	80.6%	86.0%	94.8%
	C/$D	37 cents	57 cents	102 cents

Based on the metric cost per dollar demand, this form of VSL appears to be much more expensive than the fixed safety levels shown in Table 5-7. However, as shown in Table 5-9, the two computations differ in the individual item GIE rates that they generated. For Table 5-9, we selected 1-month order quantity and 1/2-month safety level because it was the most cost-effective fixed levels alternative. We selected EOQ and 75 percent safety level because it was the most cost-effective variable levels alternative.

Table 5-9. Item Performance Distributions for Fixed and Variable Safety Levels

Depot	Alternative	Percent of parts with issue effectiveness in given range				
		0.50 to 0.60	0.61 to 0.70	0.71 to 0.80	0.81 to 0.90	0.91 to 1.00
Anniston	1-month order quantity and 1/2-month safety level	27	50	15	5	2
	EOQ and 75 percent VSL	0	0	68	25	7
Cherry Point	1-month order quantity and 1/2-month safety level	25	56	0	0	19
	EOQ and 75 percent VSL	0	0	76	17	7
Oklahoma City	1-month order quantity and 1/2-month safety level	81	12	4	2	1
	EOQ and 75 percent VSL	0	0	95	4	1

SUMMARY OF TEST RESULTS

Our tests reaffirmed the following axioms in inventory control theory:

- Large order quantities increase issue effectiveness, but also increase the costs of inventories.
- Large safety levels also improve issue effectiveness and increase the cost of inventories.
- Safety level increases are more effective in controlling cost and achieving performance goals than increases in order quantities.

- EOQs are more cost-effective than days-of-supply order quantities.
- Compared to days-of-supply safety levels, VSLs provide more broad-based support and more easily accommodate changes in performance goals.

Funding of Local Inventories

At maintenance depots, we found several approaches to the funding of parts inventories. Table 5-10 lists the approaches.

Table 5-10. Approaches to Funding Local Parts Inventories

Case	Number of local inventories	Funding source	Type of funding
1	1 (distributed among maintenance shops)	Industrially funded	Funded maintenance work order
2	1 (distributed among maintenance shops)	Industrially funded	Revolving fund
3	1 (central supply with forward stockage in maintenance shops)	Stock funded	Revolving fund
4	2 (one distributed among maintenance shops and a central regional supply)	Industrially and stock funded	Revolving fund

Our concern with case 1 is the timing between when funds are available to requisition parts and when a funded work order is received. If the depot cannot requisition parts until a funded work order is received, the minimum delay in starting work is an OST. Moreover, in cases where the need for a part is not known until one is determined defective, the repair cycle time for the work order would also be extended by an OST.

We were concerned about the possibility of duplicative inventories in case 4. However, we were assured that an item was not stocked in both inventories except common use items that the shops stock for maintainers and central supply stocks for other customers.

To preclude AWP delays in starting work immediately when a program is received or until a determination is made that a part has failed, depot financial policies should be revised or clarified as follows:

- Revolving-funded inventories should be used to prevent any delay in parts support for future funded work orders.
- When funded orders are received, the depot should take parts from inventory, the associated project should be charged for the parts, and the funds should be returned to the revolving fund.

CONCLUSIONS AND RECOMMENDATIONS

As a result of our analysis of local parts availability, we conclude the following:

- Local inventories at maintenance depots are critical components of part support but do not meet stated goals.
- The low predictability of part usage and end item repair programs at maintenance depots makes parts forecasting a difficult task, beset by high levels of errors.
- Days-of-supply inventory levels used by some depot activities are less efficient and effective than EOQs and VSLs.
- Some depots limit local inventories because financial authority, perceived or real, is not adequate.

We recommend that the military services continue to improve their depot BOMs and consider the potential process improvements to their demand forecasting at maintenance depots that are listed in Chapter 7.

We recommend that the military services improve their level setting at maintenance depots. Stockage criteria should consider not only demand but also the time to receive the part from a source of supply and the cost of stocking or not stocking the item. Moreover, depots should replace days-of-supply algorithms with EOQ and VSL algorithms.

Finally, we recommend changing financial policies that prohibit local inventories from maintaining parts in anticipation of future work orders. Local inventories may be subject to budgetary limitations, but they should not be prohibited.

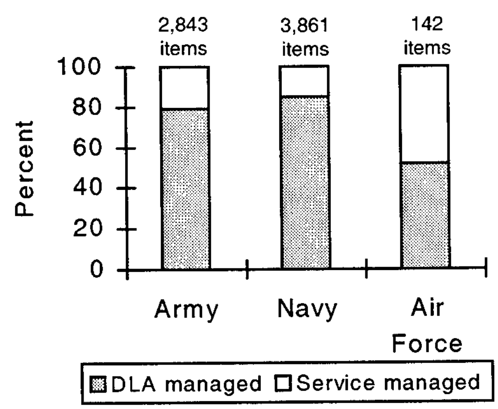
Chapter 6
DoD Wholesale Parts Availability

This chapter discusses the nonavailability of parts from DoD ICPs that support maintenance depots. To identify problems causing parts not to be available at the wholesale level, we conducted interviews, reviewed historical backorder data, and evaluated item case studies. This chapter explains the importance of wholesale availability and discusses the causes of wholesale backorders and potential process improvements to reduce wholesale delays.

DLA Focus

The focus of our wholesale analysis is primarily parts managed by DLA. Figure 6-1 depicts our samples by DLA and military service source of supply. With the exception of the Air Force, most AWP parts are consumable items managed by DLA.

Figure 6-1. Managers of Sample Items Causing AWP



The difference between the Air Force sample and the Army and Navy samples is explained by the following:

- ◆ The Air Force sample includes reparable items being routed through repair shops.
- ◆ Similar items are not in the Army and Navy samples because their shop times were below the minimum times that the Army and Navy place on recording AWP items.

IMPORTANCE OF WHOLESALE AVAILABILITY

Because depot repair is dynamic, maintenance depots never maintain enough stock to guarantee 100 percent issue effectiveness. Consequently, they rely on their principal parts supplier, DLA, to replenish stocks and fill shortfalls. DLA causes AWP delays when it cannot fill high-priority requisitions for parts that are not available at maintenance depots.

ICP Performance Measures

DLA ICPs measure their performance in terms of supply availability rates (synonymous with percent of immediate issues). Although the rates are important to maintenance depots, requisition response times and time on backorder are also important. As shown in Table 5-2, when the measures are combined, they define the average time a maintainer waits for a critical part.

Table 6-1 compares the data for maintenance depots to similar data for other customers.[1]

Table 6-1. FY97 Requisition Performance Data for DLA Supply Center

Performance indicator	Maintenance depots	Other customers
High-priority requisitions		
Supply availability	67.4%	76.5%
Average time from date of requisition to shipped date for immediate issues	12 days	22 days
Average time from date of requisition to shipped date for backordered issues	406 days	289 days
Low-priority requisitions		
Supply availability	87.1%	78.8%
Average time from date of requisition to shipped date for immediate issues	11 days	41 days
Average time from date of requisition to shipped date for backordered issues	255 days	223 days

The measures in Table 6-1 should be indicative of the level of parts support to maintenance depots provided by other DLA and organic sources of supply. The

[1] The data were compiled from a requisition history file containing all requisitions received by the DLA aviation support supply center in FY97. Open requisitions were not included in our computations. Cancelled and rejected requisitions were also extracted for separate analysis.

measures show that, when support for maintenance depots is compared to support for other customers, depots experience the following:

- For high-priority demands, less immediate fills and longer backorder times
- For low-priority demands, more immediate fills but longer backorder times.

As previously stated, high-priority requisitions (priorities 01, 02, and 03) are AWP requisitions. Low-priority requisitions (priorities 09 through 15) are characteristic of replenishment requisitions.[2] The requisitioner—not a policy or procedure that the ICP employs for maintenance depots—determines the priority selected. The wide range of support given to depots confirms this finding. Table 6-2 shows how support differs among the six depots we visited.

Table 6-2. FY97 Requisition Performance Data

	High-priority or AWP requisitions		Low-priority or replenishment requisitions	
Depot	Supply availability (%)	Time to process a backorder (days)	Supply availability (%)	Time to process a backorder (days)
Anniston	77.6	304	78.2	173
Cherry Point	68.2	482	88.3	280
Corpus Christi	72.7	422	87.3	170
Jacksonville	65.3	416	74.8	452
Oklahoma City	64.6	373	92.0	165
Warner Robins	65.9	397	88.8	259

Why Parts Are Not Available from the DoD Supply System

Parts are not available at the wholesale level for many reasons. In 1996, an LRT team, lead by the then Materiel and Distribution Management Office of the Office of the Secretary of Defense, analyzed the reasons for wholesale backorders. The team identified 48 reasons comprised in the following 6 groups:

- Unforecasted demand
- Increased lead-time (including administrative, production, and repair times)
- Item management problem (e.g., obsolete item, logistics transfer)

[2] Although the depots use priority 03 for AWP requisitions and priority 13 for replenishment requisitions, we used the full range of issue priority groups I and III to make a fair comparison of support to depots and support to other customers.

- Problem with contractor (e.g., default, cancelled contract)
- Problem with demand (e.g., unfunded, no fielding of associated end item)
- Asset problem (e.g., litigation).

For items with many backorders, the leading causes were increased lead-time (43 percent) and unforecasted demand (23 percent). For items with very long backorder times, the leading causes were item management problems (40 percent) and increased lead-time (31 percent).

In the sections that follow, we discuss our analyses of increased procurement lead-times (perhaps the leading cause of long backorder times that, in turn, cause long AWP delays), management of low demand frequency items, forecasting wholesale repair parts demand, and requisition processing of depot AWP demands. Appendix C addresses other activities that aggravate or improve wholesale availability.

INCREASED PROCUREMENT LEAD-TIMES

Wholesale procurement lead-times are the sum of administrative lead-times (ALTs)[3] and production lead-times (PLTs).[4] The inventory managers we interviewed believe that both the length and variability of procurement lead-times cause backorders frequently. (We were able to confirm this supposition in our case study of wholesale contracting for parts causing work stoppages.)

To test the importance of lead-times on the number and length of backorders, we ran an inventory simulator using DLA data. For the simulation, we used item safety levels, demands, and lead-times. We held safety levels and demands constant and tested decreases in lead-times. Table 6-3 depicts decreases in backorders as lead-times decline. Expected backorders are the product of the number of backorders and the time on backorder.

Table 6-3. Lead-Time Reduction and Backorders

Type of change	Percent change								
Reduction in lead-times	0	10	20	30	40	50	60	70	80
Decrease in backorders	0	14	27	40	51	62	71	79	85

The reorder point to replenish most DoD wholesale stock levels is predicated on accurate forecasts of demand, ALT, and PLT. The safety level of demand-based items (NSO items have no safety level) is intended to cover the variance in demand during the lead-time. The safety level computation does not cover the

[3] From start of procurement action to date of award.

[4] From date of award to date of delivery.

variance in the lead-times. Further, differences between the file lead-times and those experienced cause additional variance.

Contributing Factors

The following factors contribute to long ALTs:

- Contracting methods
- Value of the procurement
- Lack of current technical data
- Buyer workloads and backlogs
- Internal procurement approval reviews
- Lack of sources (including diminishing manufacturing sources and the demise of original equipment manufacturers)
- Lack of contractor interest in small-value procurements, and extended life and age of weapon systems supported.

The following factors contribute to long PLTs:

- Acquisition of materiel needed for production (68 percent of the production lead-time)[5]
- Unwillingness of contractors to commit to short times (concern with being delinquent)
- Inadequate consideration of required delivery dates in contract negotiation
- Requirements for first article testing
- Poor customer treatment because the relationship between the government and the contractor is short term
- Production scheduling.

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[5] Logistics Management Institute, *Procurement Lead Time, The Forgotten Factor,* Report ML515, James H. Perry, Inta Silins, and Lloyd B. Embry, September 1986.

Potential Process Improvements

Process Improvement 1—Head Start Reorder Point

Reliable forecasts of demand and procurement lead-times are needed to establish DoD reorder points. When a reorder point is breached, an increase in ALT that exceeds the level of protection given by the safety level may cause backorders. At that point, it is too late for an item manager to correct lead-time factors.

Increased ALTs can often be traced to the following high-risk parts:

- Parts recently transferred to an item manager
- Parts not recently procured
- Parts that are technically unstable
- Parts with diminishing sources
- Parts requiring first article testing.

One approach to resolving this problem caused by high-risk parts is to establish a new checkpoint 60 to 90 days before the reorder point for them. At the new point, the item manager checks the technical and source data for the item and determines if the part's reorder point needs to be revised or takes actions to ensure the uninterrupted flow of stock. For parts requiring no special action, their normal reorder points initiate procurement actions.

Process Improvement 2—Corporate Contracts

DoD generally procures items when they breach their reorder points. Usually, the contracts are firm-fixed-price, are limited to an EOQ for a single item, and are awarded to one source of supply. In this practice, multiple contracts are awarded in a year for an item from a source. Most items examined in our case studies were procured by this practice.

DoD is changing to a new practice that involves corporate contracts. A corporate contract is a single contract covering all items offered by a major commercial source of supply for 1 or more years. Corporate contracts can incorporate the following best business practices of the private sector:

- Multiyear contracts
- Multi-item contracts
- Indefinite delivery contracts (requirements and indefinite quantity).

Contracting with a single source for a large number of items over an extended period of time has some risk. First, if any problem should arise (e.g., strike, natural disaster, bankruptcy, production problem, default), many items could be adversely affected. Delays could occur while new sources are sought. Second, awarding the total requirement to a single source for an extended period may reduce or eliminate competition later when DoD needs to reprocure the item. Therefore, multiple awards should be considered.

Multiple sourcing is consistent with the concept of corporate contracts. It results in more contracts than the case with single source contracts but less than the practice of contracting for each buy requirement for a set of items. Therefore, multiple corporate sourcing retains most of the major benefits of corporate contracts while enhancing competition and reducing the risk associated with a single source. The benefits are the following:

- Fewer contracts and larger contract values, providing greater leverage, making the contracts more appealing to industry, attracting competition, and achieving some reductions in PLT
- A separation of the contracting process from the inventory management ordering system, resulting in very short ALTs (1 to 5 days), reduced costs to order, smaller EOQ quantities, and reduced response time to adjust to changes in demand
- Lower reorder points for both demand-based and NSO parts because of reduced lead-times, thereby reducing the potential AWP delay caused by a part
- Substantial reductions in the administrative workload and cost of item managers, contracting offices, and contractors
- Fewer problems in obtaining bids for low-demand parts because they are combined with high-demand parts in a single package.

Process Improvement 3—Greater Emphasis on Performance in Contracting

Awarding a contract does not resolve an AWP problem if the contractor has an extended PLT to deliver or if the contractor is delinquent. Thus, performance needs to be an integral part of solicitation, bid evaluation, and contractor performance evaluation.

Solicitations should clearly define performance requirements (e.g., required delivery times and on-time delivery rates) and rewards and penalties for meeting or not meeting those requirements. They also should allow contractors to bid alternative performance requirements (e.g., shorter PLTs) and materiel support options (e.g., direct vendor delivery).

The cost analysis of bid evaluation should consider PLT reduction as a saving. Proposed support options should be evaluated from a supply chain rather than a wholesale perspective.

Performance evaluation should measure performance and identify rewards or penalties.[6] Some key performance measurements are total supply availability (not only in-stock parts), response time for all orders, backorder age, and PLTs for out-of-stock parts.

MANAGEMENT OF LOW DEMAND FREQUENCY ITEMS

DLA-managed parts are consumable items that are managed as nonstocked (buy-on-demand or local purchase) or stocked items. If they are stocked, they are NSO or quarterly forecast demand or replenishment items (i.e., items with EOQs and VSLs). In general, items are stocked if they have 4 or more demands in 12 months (4-in-12 rule).[7] Once stocked, items may continue to be stocked even if their demand declines.

For this study, low demand frequency items are items that DLA stocks as NSO items or items DLA does not stock because they do not meet the 4-in-12 rule. By policy, nonstocked items convert to NSO items when one of the following occurs:

- They have 4 demands in 12 months.
- They are identified by a high essentiality code as critical items.
- They have an accumulated supply support request quantity of 5 or more.
- They have on-hand assets.

If NSO items have 4 demands and a quantity of 12 or more, they convert to replenishment items. Consequently, NSO items generally do not have enough demand to generate a viable forecast that supports EOQ and VSL computations.

Low Demand Frequency Items and AWP

As shown in Table 6-5, in our AWP samples, parts with low demand frequency (i.e., NSO and nonstocked items) account for approximately 38 percent of the

[6] The Navy has developed software that improves the process and provides contractor performance data daily. The software is provided free to contractors. It converts order transactions into shipping documentation, including DD Form 1348. It also generates performance data to the ICP daily. Monthly performance reports are used to evaluate contractors.

[7] As we noted for retail range rules, their effectiveness and efficiency are questionable. More logical rules would consider the expected time to buy materiel from commercial sources, the cost of stocking the part, and the expected priority of demand. (For example, if two parts are the same except one part is always ordered with a high priority, that part should have the advantage.)

number of items. Table 6-4 includes items managed by DLA and the military services.

Table 6-4. Wholesale Management of Sample Parts

Source of sample	Percent		
	Stocked non-NSO	Stocked NSO	Nonstocked
Army	60	26	14
Navy	63	21	16
Air Force	66	27	7
Total	62	23	15

We found that the backorder duration for DLA-managed low demand frequency items is 40 percent longer than the average backorder duration for more frequently demanded DLA items. Therefore, AWP delays for low frequency demand items are likely to last a very long time.

Although each infrequently demanded part is likely to account for fewer AWP incidents than each frequently demanded part, collectively the number and duration of low frequency part problems warrant attention because they cause a large part of AWP delays.

Potential Process Improvement

DLA procedures for setting NSO levels do not consider an item's price, lead-time, or demand variance—factors that are key for setting levels for frequently demanded items. The rationale is that, without a creditable forecast, an NSO should be assigned a numeric level, and one half of the level should be the reorder point. The level is often based on the item's most recent demand history (e.g., last year's demand).

Low But Regular Demand

While demand for an NSO item is low, if it is fairly regular or level over time, then last year's demand is a stable basis for computing NSO quantities. It may also be a stable basis for computing lead-time demand. If this case applies, an alternative for improving support for NSO items would be to set the NSO reorder point to the item's lead-time demand instead of one half the NSO level.

Low and Irregular Demand

However, we need to be concerned if the normal situation for infrequently demanded items is not regular demand; that is, demand occurs at irregularly spaced

intervals with spikes from one to thousands of units. We examined more than 500,000 NSO items at one DLA supply center and found this case to exist.[8]

For such items, last year's demand may not be a valid basis for NSO levels, particularly when the time between spikes is greater than a year. A better approach might be one that considers peaks and the probability that they may reoccur. If NSO levels were set equal to a portion of past peaks, they might cover a portion of future peaks.

Unlike the current approach, this approach offers the possibility of relating an expected level of supply performance with a level of inventory investment. Supply managers would be able to tailor the level of support for infrequently demanded parts based on customers' desired supply performance and available funds. Preliminary tests we conducted indicate that the stock levels at one supply center would be from 0 to 5 units for more than 90 percent of the parts.

However, within the scope of this study, we could not test all refinements needed to implement peak-based levels. The refinements should include the following:

- *Probability that an item will have a future peak demand.* Some low demand frequency items do not have a recurring pattern of peaks.
- *Price of the item.* The computational model for NSO levels can use price information to optimize the level of investment for a level of supply performance.
- *Lead-time.* Time on backorder, a function of lead-time, should be part of the supply performance goal of the computational model.

FORECASTING WHOLESALE REPAIR PART DEMANDS

Although the demand placed on the wholesale level of supply blends the demand peaks and ebbs of retail sites and consequently has a smoother, more stable pattern, it is difficult to forecast. One reason is lumpy demand. Retail demand for frequently demanded parts is lumpy because retail activities order parts in lot sizes to replenish their inventories.

Another source of lumpy demand is the occasional peaks in demand caused by special programs or surges in activities. For example, a maintenance program to restore equipment returning from a military operation causes a surge in repair parts. If wholesale demand forecasts are based solely on historical demand, they do not properly account for such surges.

[8] For more than 99 percent of the items we examined, the peak lead-time demand for the item was the same as the peak quarterly demand.

Current Practices in Predicting Wholesale Demand

To develop the best possible wholesale forecasts, DLA and the military services maintain long histories of demand to study long-term trends and evaluate alternative forecasting models. They also use statistical process control techniques to reduce the negative impacts of abnormally large demands.

Where a relationship exists between operational program data and expected usage, the military services use program data in their forecasts. For example, the Air Force uses a flying program to forecast demand for DLR items, and the Army uses end item densities to forecast demand for associated components.

Finally, the military services encourage retail activities to give advanced notice of known future demand. SPR process allows activities to send a special future demand to the wholesale manager.[9] Maintenance depots can use SPR process to send future forecasts based on their projected repair programs. The wholesale manager checks if the future demands can be filled or if pending buys need to be increased.

Problems with Transfer of Program Data

Item managers we interviewed identified three problems with SPR process:

- SPRs are received too late (i.e., less than a procurement lead-time in advance of the required date and too late to initiate a procurement action).[10]
- SPRs are received, but no subsequent requisitions are placed against them.
- Programs that have SPR-qualified requirements are not submitting SPRs before submitting requisitions.

In all cases, the impact is the greatest when the SPR or potential SPR is the only requirement for an item.

[9] Department of Defense, *Military Standard Transaction and Accounting Procedures (MILSTRAP)*, DoD Manual 4000.25-2-M, May 1987, defines an SPR and prescribes procedures for its submission. Chapter 13 of the manual has "procedures for forecasting requirements for items required to support special programs or projects that are of a non-repetitive nature and cannot be forecast by the ICP based on demand data, and that have the greatest probability of materializing and resulting in the eventual submission of requisitions." The manual also states that SPR transactions are submitted for requirements that meet 1 of 10 criteria. Two criteria have application to depot maintenance requirements. They are "repair or rebuild programs that are either nonrecurring or that are seldom or irregularly programmed" and "one-time alterations, modifications, or conversion programs."

[10] MILSTRAP limits SPRs "to materiel required not less than 90 calendar days in advance of or more than 5 years prior to the support date (the first day of the month that it is anticipated that materiel will be requisitioned for the program) indicated in the request."

SPR process is experiencing problems. The military services have several interpretations as to when and where an SPR should be used.[11] The ICPs are reluctant to buy SPR stock because they lack confidence that the planned requirements will occur. In Chapter 5, we discuss program and usage variances as factors causing parts forecasts to be inaccurate that, in turn, cause SPR quantities to be inaccurate. Another factor affecting the accuracy of SPR requirements occurs when a maintenance depot uses an alternative source of supply (e.g., local procurement, local manufacture, and cannibalization of excess equipment) to fill rejected or otherwise delayed requisitions.[12] If these demands were part of an SPR but satisfied by alternative sources, the ICPs would see less demand than expected for the SPR process.

Potential Process Improvement

Improved forecasting of depot demand for parts should improve wholesale parts availability. One alternative for improving forecasting is to expand the SPR concept and use program data (i.e., depot workload schedules) to build better forecasts. Suggested procedures for the new alternative are as follows:

- All activities that develop depot repair and overhaul programs would quarterly provide workload requirements for the current fiscal year, the apportionment year, and the budget year. Requirements would be by quarter.
- Each depot would use the requirements to compute parts requirements for 10 quarters for all items coded as centrally managed.[13] Parts requirements would reflect the quantities that the depots expect to requisition from the wholesale system. The depots would compute and forward them to the appropriate ICPs quarterly. Each quarterly submission would be a complete replacement for the previous submission rather than an increase or decrease.
- Each ICP would make a separate quarterly forecast for the items used by maintenance depots. The forecast would combine the typical forecast based on historical demand with the forecast based on the depot submissions of parts requirements. The weight of each forecast in the combined forecast depends on its respective error. For the depot-based forecast, the

[11] One military service considers all depot maintenance programs as nonrecurring because the mix and quantities of items to be repaired change frequently. Other services have a more restrictive interpretation.

[12] Maintenance depots have stopped providing data on demands filled by alternate sources to ICPs because they believed that the data were not used. If a depot has an active requisition, it should cancel the requisition. Demands are not captured in the wholesale forecasting system. (Retail systems, such as Materiel Resources Planning II, record all usage without regard to the source.)

[13] Depots would track changes in workload requirements and use historical differences between actual and projected requirements to adjust their computation of parts requirements.

error is the difference between actual demand for a quarter from each depot and the projected requirement for that quarter.

This alternative improves the information exchange between depots and ICPs because it provides continuous data submissions of expected customer requirements. It also facilitates an evaluation of the submissions. However, it would require the depots to develop new procedures and systems for submitting requirements as well as numerous changes to wholesale systems that forecast demand. Consequently, a cost-benefit analysis is needed. That analysis, which is outside the scope of this study, should determine the expected improvement in wholesale demand forecasts and estimate the impact on supply performance and inventory costs. If the improvements are significant, the analysis should identify the cost of the best way to implement the alternative.

PROCESSING DEPOT AWP REQUISITIONS

During our discussions on the causes of AWP, depot personnel identified requisition processing as a possible source of AWP delays. Subsequently, we looked at possible problems with the following:

- Depot requisitions with inadequate priority
- Unrecorded demand
- Cancelled and rejected demands
- Inadequate maximum release quantities.

We found evidence of a problem with the time to process cancelled and rejected demand. Appendix D presents our findings in the other areas.

Requisitions can be cancelled by their originators or rejected by the wholesale source of supply for several reasons, such as errors in data fields or inability to procure. Table 6-5 shows that, although maintenance depots experience fewer cancellations and rejections than other retail supply activities, the average time to perform these actions for maintenance depots is more than 60 days greater than for nondepot customers.

Table 6-5. Cancellations and Rejections

Source of demand	Percent of requisitions	Average time to cancel or reject (days)
Depot	11.50	121.4
Nondepot	13.10	66.9

To investigate potential problems with cancelled or rejected depot requisitions, we performed limited case studies and found the following:

- A large portion of rejected requisitions results from the requested parts being coded incorrectly as actively managed when they are terminal items.
- Parts changing from organic to commercial support can be mistakenly rejected.
- Many requisitions were cancelled after being on file for almost a full procurement lead-time.

Conclusions and Recommendations

Based on our analysis, we conclude the following:

- DLA supply policies and practices are the same for depot and other customers but support varies by customer.
- In the aggregate, DLA performance measures are worse for maintenance depots than for other customers.
- The acquisition process, including sourcing and contracting with large variances in ALT and PLT, is a major contributor to AWP-related backorders.
- Low frequency demand parts (i.e., NSO and nonstocked items) that cause AWP delays are on backorder for long periods of time.
- SPR process communicates depot demand projections to DLA ICPs very poorly. Participation in the program is weak, and the program cannot handle the changes to repair and overhaul programs.
- Rejections, which increase the time to receive parts, can be avoided with up-to-date coding of item management status.

We recommend that:

- The military services and DLA implement process improvements that involve head start reorder points, corporate contracting with multiple sourcing, and a greater emphasis on performance in contracting.
- DLA consider the adoption of a new algorithm that considers peak demand for setting NSO levels.

- The maintenance depots and DLA replace the SPR process. The new process would forward depot requirements periodically to the ICPs. The ICPs would treat the requirements as program demand instead of one-time additives.
- The military services and DLA should review their procedures for ensuring that item management codes are kept current.

PRIVATE-SECTOR BEST BUSINESS PRACTICES

General Observations

We noted the following:

- In comparison to DoD repair activities, private-sector repair facilities are smaller in size and workload.
- Because private-sector repair facilities are smaller, they have more direct relationships with maintenance, supply, procurement, and financial personnel.
- Because they have more direct relationships, they are able to use more effectively their parts supply chain to achieve maintenance production goals.

In spite of the differences, we identified the following six best private-sector practices that are applicable to public maintenance activities.

Practice 1, High Goals for Local Inventories

Our review of private-sector business practices focused on local supply support to repair activities. The private-sector firms set high goals for their inventories (i.e., 95 percent or higher issue effectiveness compared to the 70 percent gross effectiveness target found at most DoD maintenance depots). By increasing local depot issue effectiveness from 70 to 90 percent, DoD could reduce the average days for a depot maintainer to receive a part from 43 to 7 days.

Practice 2, Wide Range of Stocked Items

As shown in Table 5-1, the average net effectiveness rate for a depot we visited was 79.5 percent, and the gross rate was 46.9 percent. The significant difference between the two indicates that the range of stocked parts is insufficient.

One private-sector activity we visited adopted an aggressive rule for stocking parts—at least one unit of every part is stored in its supply chain. In contrast, a part used in DoD depot maintenance may not be stocked at the local or wholesale level; no quick response contract may exist with a commercial source of supply to obtain the part. When this situation occurs, maintainers wait a procurement leadtime to receive the part.

One impediment to adopting the private-sector practice of full stockage of parts is that several organizations are responsible for inventories at several levels. Moreover, an aggressive stockage rule reduces stock turn ratios, key performance metrics for DoD retail and wholesale materiel managers. Consequently, a

DLA ICP may not stock low or no demand frequency parts, although retail customers also do not stock them.

Maintenance depots may need to de-emphasize stock turn ratios and emphasize the differences between gross and net issue effectiveness. This new focus should, in turn, drive efforts to expand the range of stocked items. The issue effectiveness of one shop we visited was approximately 75 percent, in spite of its efforts to achieve 85 percent. After the shop received permission to cannibalize all usable parts from excess end items, it raised its issue effectiveness to 95 percent. This example demonstrates how a full range of parts can improve supply effectiveness.

Practice 3, ABC Management

Higher support goals and a wide range of stocked items means a greater investment in inventory. Therefore, we were particularly interested in private-sector practices that reduce or offset a high investment. One such practice is ABC management.

Across-the-board increases or decreases in inventory are usually not optimal. One private-sector facility we visited divides its population of repair parts into three categories that reflect the value of demand for the parts. Low-cost parts are in Category C; high-cost parts are in Category A; and remaining parts are in Category B. It gives Category C items the highest support goals and Category A items the lowest support goals. The goal of this ABC management is to align performance goals with inventory investment and, therefore, use inventory dollars more effectively.

Practice 4, Alternative Sources for Resupplying Parts Inventories

The same private-sector firm previously referenced uses ABC management to concentrate its efforts for reducing resupply times for Category A items. The efforts focus on establishing several sources that respond quickly to orders.

Private-sector firms informed us that they do not want to limit themselves to a single supplier unless the supplier is the only source for the component. (One firm insists on having three sources for critical repair parts.) By improving wholesale metrics (i.e., fill rates and immediate issue and backorder response times) by 10 percent, DoD could reduce the average time for a depot maintainer to receive a part from 43 to 32 days. This commercial practice supports our recommendation on multiple sourcing in Chapter 6.

Practice 5, Emphasis on Forecasting

Performance can be improved without increasing inventory levels by reducing the level of error in forecasting customer requirements. Of course, the variability in the end item repair program and the variability of parts needed to make the repairs

make it impossible to eliminate the error. However, modeling and other techniques can reduce forecast error.

We found the following modeling and other approaches in the private sector that can reduce forecast error at a depot retail supply activity:

- *Employ a suite of models to forecast the demand for a part.* This practice is employed by DoD wholesale activities and private-sector firms. Instead of one model for all parts, each part should have its best model.

- *Supplement model forecast with performance testing to determine when an end item fails and the parts that might be needed.* Materiel managers at a private-sector activity ignore forecast models for expensive end items and use periodic tests to reveal failures that may occur and the frequency of these failures. (If end items cannot be tested while they are in use, another test-related approach could be the prescreening of unserviceable items. When the failed end item is received at the wholesale distribution depot, test equipment or another means can identify before induction the major expense items required to fix it.)

- *Use ABC management to allocate resources to forecast items to achieve the greatest return.* Under ABC management, forecasts for high-cost, high-demand items would receive the most attention and resources, while forecasts for low-cost items could be generated automatically with little or no manager review or input.

- *Track failures at their source (i.e., research reasons for failure at their source and incorporate the reasons and their future potential into repair part forecasting).*

These private-sector practices are the potential process improvements that we recommended the military services consider in Chapter 5.

Practice 6, Balancing Level Loading and Critical Need Loading

Maintenance managers have normally relied on level loading to schedule work at DoD maintenance depots (e.g., quarterly requirements were divided by three to determine monthly requirements). Exceptions were introduced when a critical need developed. Level loading offers the advantage of steady work and predictable parts usage. Disadvantages with level loading involve early and over-inductions.[1]

Need-based methodologies have been emerging as the Air Force schedules and executes its DLR repair program based on the criticality of need for failed items. A need-based methodology has the advantage of working with current data,

[1] Logistics Management Institute, *The Depot Repair Cycle Process: Opportunities for Business Practice Improvement*, Report LG406MR1, Kelvin K. Kiebler et al., May 1996.

thereby reducing early and over-inductions. It has the disadvantage of continually changing work that, in turn, leads to less predictable parts usage.

Generally, the firms that we visited repaired components as they arrived. To prepare for the arrivals, they focused on better forecasting through modeling or links with customer systems (to provide an early warning of a future need). However, one firm recognized that short-term forecasts contain errors and can change daily. Therefore, for items that were the biggest contributors to the total cost of repair, the firm adopted a longer forecast and level loaded against the forecast. (Longer forecasts generally accommodate peaks and valleys in demand, thereby providing greater stability than short-term forecasts. However, they are less responsiveness to upward and downward trends.) The level loading of end items entering repair tends to level the demand for expensive parts used to repair the end items. In turn, this leveling of demand contributes to more efficient forecasting and inventory levels for the repair parts.

The Navy practices a similar approach. It schedules repairs for items that account for most of its repair costs and repairs the others as needed. As is the case with the private-sector firm, the minority of items but majority of repair dollars are level loaded, while the majority of items and minority of repair dollars are scheduled for repair as needed. The Army and Air Force might consider this approach.

Cost-Effectiveness Considerations

Although private-sector firms track AWP delays, no firm we investigated determines the cost of AWP delays. Instead, it relies on lost sale penalties to decide initiatives that are cost-effective in overcoming AWP delays. For example, the loss of a commercial aircraft means a cancelled flight with an associated loss of revenue. Private-sector maintainers can use a factor of lost revenue to decide actions that are cost-effective in obtaining parts.

However, DoD aviation maintenance managers have no such factors. The loss of a military aircraft in peacetime has no associated loss of revenue, although the loss of an aircraft may cause a military unit to fail to reach its goals for flying hours and sorties. In wartime, aircraft shortages hinder mission effectiveness. Until the military services develop cost factors for not having aircraft or other major end items, DoD maintenance depots do not have a cost standard to judge initiatives that are cost-effective in overcoming an AWP delay.

CONCLUSIONS AND RECOMMENDATIONS

As a result of our analysis of private-sector business practices, we conclude that local repair parts support can be improved through better business practices that the private sector uses. All practices are applicable to the Defense Department.

We recommend that the military services take the following actions:

- Increase gross issue effectiveness goals at maintenance depots.
- De-emphasize stock turn ratios as supply management goals at maintenance depots and adopt aggressive stockage rules (e.g., use stock turn ratios as part of a "balanced scorecard").
- Apply ABC parts management at retail activities supporting depot maintenance to allocate inventories and other materiel management resources more effectively.
- Help reduce variability in demands for parts by establishing a level load program for end items that are expensive to repair because of the high price and high variability of repair parts.

Appendix A
Depot Actions to Overcome AWP and Sample Costs

Financial systems for DoD maintenance depots do not collect AWP cost data. Rather, those costs are included in the direct, indirect, materiel, and general and administrative costs that comprise the cost of repair.

Consequently, we were not able to collect comprehensive data on the costs of efforts to overcome AWP problems. Instead, we used available data and assumptions to derive values for those costs. This appendix addresses the costs of expediting, the costs of cannibalizing assets, local purchase costs, reclamation costs, local manufacturing costs, lateral distribution costs, and reengineering costs.

COSTS OF EXPEDITING

Expeditors are used to bring item manager attention to requisitions for items that are causing an end item to be AWP. The goal is to engage the item manager in trying to satisfy those requisitions more quickly. The Navy repair part supply chain has the most expeditors, including online maintainers, site expeditors, DLA site reps, and NAVICP personnel.

Our survey of the estimated costs for site expeditors found the following:[1]

- Oklahoma City ALC estimates that 40 of the 74 persons who are managing parts spend 60 percent of their time expediting parts that cause AWP delays. The cost of this workload is approximately $958,000 per year, or $7.31 per AWP incident.
- Corpus Christi AD estimates that 25 to 40 percent of its program managers' time and 30 to 80 percent of its parts managers' time are spent on expediting. The cost of this workload is between $341,000 and $808,000 per year, or between $3.20 and $7.59 per AWP incident.

COSTS OF CANNIBALIZING ASSETS

Maintainers take parts from one end item to complete the repair of another end item. Cannibalization of parts can occur when the end item is in storage or repair.

Normally, end items in storage are subject to cannibalization when they are in excess or no longer needed by DoD. Typically, separate cost data are not maintained

[1] Assuming a salary in 1999 for a GS-9.

on the cost of this type of cannibalization except when excess end items are inducted solely for parts cannibalization. Cherry Point provided a report showing $11,099 as the cost of cannibalization for one month.

For end items in repair, the military services use the terms "backrob" or "robback" to refer to another type of cannibalization, namely, robbing from one end item in the repair line to fix another end item that is closer to completion. Backrobs or robbacks are not as well documented as the cannibalization of excesses. The following are examples of costs that we collected:

- A Cherry Point report indicated $97,188 as the cost of backrobbing for a month.
- A Cherry Point report indicated a total cost of $1,900,126 for 2 years (FY97 and FY98).
- One aircraft line at Corpus Christi AD estimated its annual robback cost was $217,442 for 490 incidents.

LOCAL PURCHASE COSTS

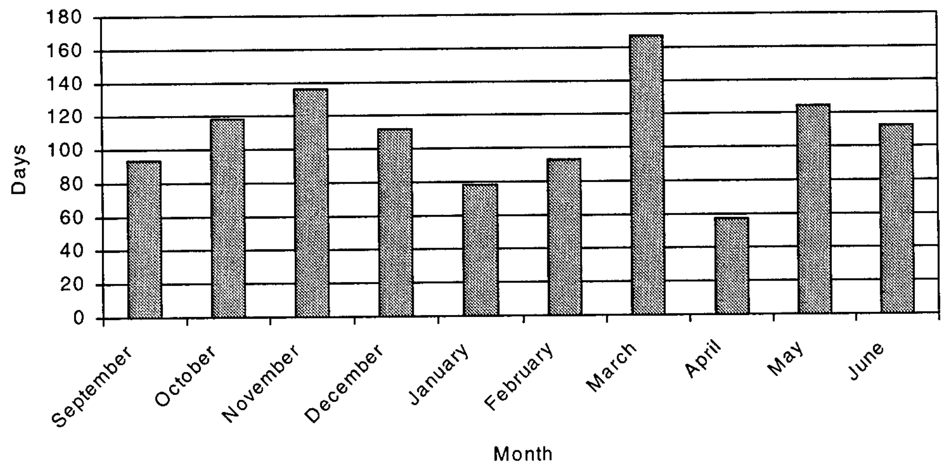
Depot maintainers use local purchases to obtain parts that are not available from the DoD supply system. The process starts when a maintainer decides that a local purchase should be used to satisfy a part shortage. The maintainer identifies potential vendors. Depending on the value of a part, the maintainer can order it using a credit card or send the order to the local procurement office, which orders the part using a credit card or another form of local purchase.

The procurement office at Anniston AD charges $500 for a normal purchase and $250 for a credit card purchase. These charges do not include the cost of the maintainer collecting the information to make the purchase.

Another consideration in evaluating costs is the inherent delay in making a local purchase. Cherry Point data, presented in Figure A-1, demonstrate that local purchase is not very fast.

Figure A-1 shows the monthly average ranges from 58 to 167 days. These times should be better when the maintainer makes the local purchase using a credit card. However, compared to normal requisition times of less than 30 days, these times are very extended.

Figure A-1. Monthly Averages for Local Purchase Time (Cherry Point)



Reclamation Costs

In some instances, parts can be salvaged or reclaimed from end items designated for disposal or from unserviceable consumable parts that can be repaired. We collected the following two examples of reclamation costs:

- The cost of reclamation at Anniston AD was 31 percent of the cost of buying new parts.
- The cost of reclamation to fill a critical item shortage needed for the B-52 at Oklahoma City ALC was 76 percent of the cost of buying a new part.

Of course, reclamation is not always possible if parts are not available to be reclaimed. For example, in the case of the B-52 part shortage, reclamation provided only some of the needed parts.

Local Manufacturing Costs

To fabricate repair parts that are not otherwise available, maintenance depots have developed a local manufacturing capability. For some parts, local manufacturing is the source of supply. For other parts, local manufacturing becomes a source of supply when the normal source of supply is out of stock. For a sample of fabricated items at Anniston AD, the average cost to fabricate an item was 12 times more than its purchase price.

We also collected the following fabrication times, which are significant:

- Monthly average fabrication times at Cherry Point ranged from 79 to 135 days.
- The average at Corpus Christi AD was 115 days with a median of 89 days.

Lateral Distribution Costs

If a depot's source of supply is out of stock, the depot may check with other customers for an item. If they have stock, a lateral issue between the activity with stock and the depot may be possible.

However, the depots indicated that little activity is spent on obtaining supplies from other users. On the contrary, depots noted that lateral issues often occur the other way. That is, parts that operational units need for repair are released from depot stocks. We did not collect cost data on this action.

Reengineering Costs

If a maintainer cannot get a part from a source, the last course of action is to request a substitution from the equipment engineer. If the engineer does not have a substitute readily available, a reengineering action may be needed to provide the substitute. We did not collect cost data on this action.

Appendix B
Other Activities Affecting Local Parts Availability

This appendix describes other activities that affect local retail parts availability. These activities aggravate as well as reduce problems in making parts available.

Activities That Aggravate Problems in Making Parts Locally Available

Three nonrecurring activities—transfers in depot missions, extended life cycles of weapon systems, and information system changes—aggravate problems in making parts locally available.

Transfers in Depot Missions

The workload of Naval aviation depots and Air Force ALCs being closed is being transferred to gaining depots. If the gaining depot does not have first-hand knowledge of expected parts demand, it has to rely on data from the losing depot. Gaining depots consider the data from the losing depot not as viable as the first-hand knowledge. Until they gain first-hand knowledge, they experience more parts shortages than usual.

Extended Life Cycles of Weapon Systems

The average age of all Air Force aircraft is almost 20 years and will continue to increase in the next few years. The other military services also encounter aging weapon systems as weapon system life cycles are extended until modernization programs can provide replacement systems. The extended lives of weapon systems contribute to AWP in the following two ways:

- The technology of components in a system becomes outdated. Original equipment manufacturers for many parts no longer make the parts or exist, creating technical data and sourcing problems.
- Major modifications are introduced without being provisioned. When requisitions are received for the new items, the supply system is frequently lead-time away from providing support. ICPs need to obtain technical data and find sources for first-time buys. If they do not, the result is a delay.

Information System Changes

DLA recently initiated steps to improve and standardize the management information system at its distribution depots, including those collocated with maintenance depots. The introduction of the new system initially caused interface problems with the maintenance systems that needed to be resolved.

One problem involved the communication of expected due-ins between the two systems. This problem caused the distribution depot to receive stock that it did not know was marked for the maintenance depot. Therefore, the stock was placed in storage while the maintenance depot was looking for it. The depot overcame this problem by going offline to reconcile receipts with due-ins.

ACTIVITIES THAT REDUCE PROBLEMS IN MAKING PARTS LOCALLY AVAILABLE

The following initiatives pose opportunities for reducing AWP times.

On-Site Customer Service Representatives

DLA has placed customer service representatives at DoD maintenance depots. NAVICP has also placed representatives on-site at aviation depots. The representatives help depots satisfy their parts needs by

- educating personnel on the procedures for ordering parts;
- seeking ways to improve service between service maintenance depots and distribution depots, which DLA manages; and
- expediting critical parts requests or establishing alternative sources of supply.

As a result of the emphasis on customer service at DoD maintenance depots, AWP delays are prevented or reduced.

Parts Jobbers

Third-party parts jobbers can have an important role in satisfying critical depot needs. Their focus is on finding a source for a needed part. They are familiar with the marketplace and less constrained by acquisition regulations. The military services use part jobbers to fill needs that cannot be met through standard procedures, primarily for special or hard-to-find parts.

Internet Search Capability

Several depots we visited use parts services on the Internet to obtain hard-to-get parts. The depots subscribe to the commercial Inventory Locator Service (ILS). With ILS, manufacturers and parts distributors use the Internet to list parts that are available. Subscribers can interrogate the lists to determine the location and quantity of parts available. This service and similar Internet services can help reduce AWP delays.

Appendix C
Other Activities Affecting Wholesale Parts Availability

This appendix describes other activities that affect wholesale parts availability. These activities aggravate and reduce problems in making parts available.

ACTIVITIES THAT AGGRAVATE PROBLEMS IN MAKING PARTS AVAILABLE

Inventory Reduction Through Lower Retention Limits

Congress, General Accounting Office, and DoD officials have sought to reduce DoD inventories. One approach for reducing inventories is to retain less stock by lowering retention limits. However, retention criteria generally do not consider the expected life of the weapon systems or a decision to extend it. These shortfalls result in the disposal of items that subsequently are required and difficult to procure.

To illustrate this point, we examined the disposal history of 94 AWP parts. We found that 15 percent had disposals in the last 6 years, and 12 percent in the last 2 years. However, to satisfy the AWP conditions, the parts were being purchased locally, manufactured locally, or placed on backorder. As a result, the first and second sources searched by maintenance depots are the Defense Reutilization and Marketing Service (DRMS) and surplus dealers that purchased "excess" materiel.

Performance Orientation of DoD Wholesale Managers

Wholesale managers, particularly DLA item managers, are often judged by the supply availability (i.e., immediate issue as a percent of all requisitions) of the items that they manage. Consequently, this orientation results in the following:

- Managers manage items, not requisitions.
- ICPs do not track their support to a customer.
- ICPs focus their decision algorithms or procedures on achieving high levels of immediate issues and avoiding backorders instead of time on backorder (e.g., DLA procurement managers consider the number of requisitions for an item in prioritizing their workloads).

This approach is a problem for maintenance depots because all parts are needed to complete repairs, not just a percent of parts.

Transfers of Responsibilities

Transfers of integrated materiel manager (IMM) responsibilities for parts within a DoD component and between components can adversely affect supply support. Losing ICPs tend to redirect resources from parts being transferred to parts they will continue to manage. Meanwhile, gaining ICP staffs may not be immediately ready to accept and perform the new workload.

Personnel at a gaining ICP frequently receive less than a full pipeline for parts being transferred. In some cases, the shortage is caused by differences in how the ICPs compute their pipeline requirements. In other cases, the shortage may be caused by

- spikes in customer demand that depleted pipeline stock,
- new customer requirements that were not part of pipeline requirements computations, and
- the need of losing ICPs to conserve financial resources.

Resource shortages occurring during IMM transfers contribute to AWP delays by causing part shortages and, in some cases, extend the lead-time to obtain needed parts. Better compliance with procedures is a solution, but may not be possible if a one-time buildup cannot be made to accomplish a smooth transfer. However, problems from the transfer of IMM responsibilities should be short-term.

Activities That Reduce Problems in Making Parts Available

Virtual Prime Vendor and Other Direct Support Contracts

To provide better and more timely support to maintenance depots, DLA seeks commercial sources of supply to provide parts directly to the depots. In our survey of DLA efforts, we found the following:

- In some cases, DLA has successfully established a virtual prime vendor that is more economical and responsive than DLA.
- In other cases, DLA and the service depot have not found a vendor more economical or responsive than DLA.
- In other cases, DLA has established a direct support vendor that has not met desired goals.

We also observed that the number of items that have changed to direct commercial support is limited. For example, the successful contract with Hamilton Standard to support the hub-and-blade shop at Warner Robins ALC is limited to 1,600 parts of the more than 20,000 parts it uses. For direct commercial support to be successful, vendors need an economical advantage. Vendors are averse to assuming the risk of failing to supply a part in a dynamic depot environment.

We examined two contracts with direct delivery provisions. Both were for sole source items and contained other features—multi-item (corporate), multiyear, and indefinite delivery. The response time standards for items causing a not mission-capable-supply condition were 48 hours from the receipt of a delivery order to shipment (i.e., twice the Uniform Materiel Movement and Issue Priority System [UMMIPS] standard of 1 day that organic depots are expected to meet for requisitions with transportation priorities 1 and 2). The standard for routine requisitions is 8 days compared to the UMMIPS standard of 3 days.

Management fees paid to the contractor vary based on a series of fill rates (percent of orders shipped within the time frames). The fee covers inventory investment and storage costs. The minimum fee is paid if the contractor does not achieve the minimum fill rate. Several exclusions from the fill rate computation are applicable. The standards do not apply from the time an item is added to the contract until the end of the normal production lead-time unless the contractor has stock. Objectives are set for the release of backorders, but neither an incentive to meet the objectives nor a penalty for not meeting them is used. However, both contractors are exceeding the 90 percent fill rate, and the age of backorders is not significant.

Backorder Management

The second area we examined is backorder management. For stocked parts, backorders occur when stock is being replenished; that is, when demand exceeds the amount of stock maintained to satisfy expected demand during a procurement lead-time. For nonstocked parts, customer demands are normally backordered, although the supplier sometimes has inventory to satisfy the demand.

Noteworthy Programs

During our visits, we noted two important backorder management initiatives. The Navy's materiel availability program at Jacksonville combines program repair part usage factors and local and wholesale asset positions to identify potential backorders early. The second initiative is DLA's Vital Signs Program. Most repair point systems of DoD supply activities, including DLA, order materiel when the inventory position (the sum of the assets on hand and on order minus the assets due out) is less than the reorder point. One consequence of this procedure is that backorders can continue to accumulate with no action by the system if the assets on order cover them. DLA's Vital Signs Program provides a means to identify this situation. It projects backorders based on expected demand and

current assets on hand and on order. It also identifies items with projected high backorders. Center personnel use the projections to initiate emergency procurements or modify existing procurements to avoid or reduce a major backorder problem.

Backorder Chasers

DoD safety levels are designed to prevent low-cost backorders. ICP emergency response capabilities are aimed at high-priority requisitions regardless of price. The combined effect is that high-cost, low-priority backorders are not pursued except by item managers. However, item managers may not have the time for identifying sources to satisfy backorders.

To fill this void in backorder management, one DLA center has hired third-party backorder chasers. The contractors find sources for satisfying high-cost backorders. By finding stock for low-priority but high-cost backorders, they may help reduce the potential for high-priority AWP requisitions. More importantly, they free item managers to work on AWP needs.

Emergency Response Capability

Quick satisfaction of an AWP backorder requires the ability to provide emergency or expedited response to an out-of-stock situation. Even in an optimistic scenario for local and wholesale availability of parts, backorders occur. Because these backorders cause AWP delays, their timely resolution is important and should be an area of management attention. Expediters at the depots and ICPs are the principal responders to critical backorders.

In Chapter 3, we discuss expediting parts when their nonavailability disrupts depot maintenance. Expediting in the maintenance activity involves production controllers, parts managers, program managers, and manufacturing division personnel. At the retail activity supporting the maintenance depot, inventory managers and contracting office personnel are involved. Frequently the wholesale representatives of the military service or DLA that are located at depot maintenance activities also participate. At the ICPs, item managers, contracting officers, and, in some cases, a customer support office are involved.

Duplication

The multiplicity of expediters undoubtedly reduces AWP delays. However, this approach is costly, but somewhat ineffective because expediters compete with each other. They pursue the same sources, such as the following:

- They query DRMS.
- They use asset visibility capabilities to seek potential redistribution assets.

- They invest in several services, such as ILS mentioned in Appendix B, to provide potential sources.
- They make emergency procurements and consider organic manufacturing.

PRIVATE SECTOR

This manpower-intensive involvement contrasts sharply with two private-sector aircraft overhaul companies we visited. The companies assign the authority and responsibility for expediting parts support for a group of items to one person. The expediters resolve problems by contacting people in functional areas, such as maintenance, inventory management, contracting, transportation, and receiving. The private-sector approach clearly fixes responsibility and authority while eliminating unnecessary duplication.

ICP CUSTOMER SERVICE OFFICE

At one ICP, we reviewed the role of its customer service office. This office is organized to perform an expediting role similar to the one we found in the private sector. The ICP's customer service office receives and processes emergency requisitions, has access to the latest status information, and has a contracting staff to perform emergency procurements from private or public sources, without involving the contracting offices supporting the product centers. It checks current contracts to determine if high-priority requisitions can be expedited.

The office uses the Internet in two ways. First, it can receive requisitions, status requests, and followups electronically that otherwise might be received on paper. This method of transmission by requisitioners accelerates response and reduces the workload to enter documents into automated systems. Second, the office provides customer access to databases with the latest information, thereby negating the need for most customer inquiries and freeing resources for expediting rather than communicating.

In summary, we found that a customer services office is a best practice. It mirrors a private-sector practice by pooling resources to terminate high-priority backorders quickly by all available means.

Appendix D
Requisition Processing

This appendix discusses the topics of requisition priority, unrecorded requisitions, and maximum release quantity that are related to requisition processing.

REQUISITION PRIORITY

For purposes of requisitioning materiel, maintenance depots are assigned designator III as a force or activity designator (FAD). The assignment allows them to submit requisitions with priorities 03, 06, and 13, depending on the urgency of need. In general, depots replenish their stocks with priority 13 requisitions and obtain out-of-stock parts with priority 03 requisitions. Occasionally, depots order materiel with a priority 02 requisition, which indicates that the work is for a FAD II unit.

Table D-1 compares the priorities of depot and other requisitions for a DLA ICP. The table shows that depots tend to use issue priority group one (IPG I) more than other customers and frequently assign high priorities to their critical needs. However, the table indicates that the depots have more critical needs than other DoD requisitioners.

Table D-1. Priorities of Requisitions

Issue priority group (priority designators)	Nondepot requisitions as a percent of all requisitions	Percent of nondepot requisitions	Depot requisitions as a percent of all requisitions	Percent of depot requisitions
I (01 to 03)	70.7	20.0	29.3	55.1
II (04 to 08)	97.6	30.8	2.6	5.5
III (09 to 15)	89.3	49.2	10.7	39.4
I to III (01 to 15)	86.9	100.0	13.1	100.0

UMMIPS assigns the fastest processing time standards to IPG I requisitions. This assignment means that requisitions for parts causing AWP conditions receive the quickest response time when stock is available at the wholesale level. If stock is not available, backorders are released in priority and date sequence.

UNRECORDED REQUISITIONS

One reason for unsuccessful requisitioning is unrecorded or missing requisitions. That is, the depot generates a requisition, but the wholesale item manager does

not receive it. During our visits, depot personnel who track the status of AWP requisitions stated that some AWP requisitions are never received by the wholesale item managers.

To investigate this possibility, we analyzed the DLA ICP requisition file. DLA creates a master record for a requisition starting with the initial transaction, which normally has an A0_ document identifier. If DLA receives a modification with an AM_ document identifier or a followup with an AT_ document identifier and this transaction is the initial transaction for the requisition, DLA uses the transaction to create the master record. Table D-2 shows the percent of high-priority requisitions (for AWP conditions) where the original requisition was not received and a modification or followup was used to create the master record.

Table D-2. Modification and Followup Percentages of Initial Requisitions

Source of demand	Initial record for high-priority demand	Percent of initial records	Average time from date of original requisition to date received by DLA (days)
Nondepot	Records other than modifications and followups	98.7	16
Depot	Records other than modifications and followups	96.3	13
Nondepot	Modifications and followups	1.3	83
Depot	Modifications and followups	3.7	75

We reviewed several cases for the depots and found that all records were modifications. Although the number of modifications is almost three times larger than that for nondepot customers, we did not find evidence that requisitions were established on the basis of a followup.

Maximum Release Quantity

To guard against erroneous entries in the quantity field of a requisition, ICPs employ maximum release quantities. The maximum DLA quantity is based on a multiple of forecasted demand. Some depot personnel believe that maximum release quantities are causes of AWP delays. Their hypothesis is that depot requisitions have higher average requisition quantities than nondepot requisitions. They believe that, because fewer end item units are repaired in the field than at the depot, depot requisitions for associated parts have larger quantities than requisitions from nondepot customers. Therefore, the demand streams should be subject to larger maximum release quantities.

Using requisition data for a DLA ICP, we identified 24,309 parts that had both depot and nondepot demand. We found the following:

- 46 percent of the parts had larger average requisition quantities for nondepot requisitions than for depot requisitions.
- 12 percent of the parts had the same average requisition quantities.
- 42 percent of the parts had smaller average requisition quantities for nondepot requisitions than for depot requisitions.

The findings do not support any change that would assign larger maximum release quantities for depot requisitions.

Appendix E
Abbreviations

AAC	acquisition advice code
AAM	Aircraft Availability Model
AD	Army Depot
ALC	Air Logistics Center
ALT	administrative lead-time
AWP	awaiting parts
BOM	bill of material
C/$D	cost per dollar demand
CMRP	Critical Maintenance Repair Parts
DLA	Defense Logistics Agency
DLR	depot-level reparable
DoD	Department of Defense
DRMS	Defense Reutilization and Marketing Service
EOQ	economic order quantity
EPS	Exchangeables Production System
FAD	force or activity designator
FY	fiscal year
G&A	general and administrative
GIE	gross issue effectiveness
ICP	inventory control point
ILS	Inventory Locator Service

IMM	integrated materiel manager
IOC	Industrial Operations Center
IPG	issue priority group
LMI	Logistics Management Institute
LRT	logistics response time
MILSTRAP	Military Standard Transaction and Accounting Procedures
NAVICP	Naval Inventory Control Point
NSO	numeric stockage objective
OST	order and shipping time
PLT	production lead-time
RTAT	repair turnaround time
SPR	special program requirements
UMMIPS	Uniform Materiel Movement and Issue Priority System
VSL	variable safety level